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The RAPS (Regional Air Pollution Study) Helicopter Air Pollution Measurement Program, St. Louis, Missouri, 1974-76

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The RAPS Helicopter Air Pollution Measurement Program, St. Louis, Missouri 1974-76

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This research program was initiated with the overall objective of providing measurement of air pollution and temperature gradient over the St. Louis, Missouri/Illinois, metropolitan area to complement surface measurements of air pollution by the Regional Air Monitoring System (RAMS) of the Regional Air Pollution Study (RAPS). Measurements aloft were made by instrumented helicopters provided with a data acquisition system for recording all aerometric data, together with navigational data and supplementary status information.

These data obtained during the 3-year period, 1974 to 1976, are intended to provide insight into the transport and diffusion processes for air pollutants and to enable model developers and other users to evaluate and analyze the suitability of simulation models for prediction and decision-making.

This report describes in detail the helicopter data collection program and catalogs the missions flown by date, time, flight pattern and purpose. These data, collected on magnetic tape, are deposited in the RAPS data bank maintained by the U.S. Environmental Protection Agency. Sufficient examples are provided, with figures and tables, to enable the prospective users of these data to understand the measurements and their limitations and so facilitate usage of the data bank.

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THE RAPS HELICOPTER AIR POLLUTION MEASUREMENT PROGRAM
ST. LOUIS, MISSOURI, 1974-1976

by

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OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
LAS VEGAS, NEVADA 89114

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DISCLAIMER

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FOREWORD

Protection of the environment requires effective regulatory actions which are based on sound technical and scientific information. This information must include the quantitative description and linking of pollutant sources, transport mechanisms, interactions, and resulting effects on man and his environment. Because of the complexities involved, assessment of specific pollutants in the environment requires a total systems approach which transcends the media of air, water and land. The Environmental Monitoring and Support Laboratory-Las Vegas contributes to the formation and enhancement of a sound monitoring data base for exposure assessment through programs designed to:

- develop and optimize systems and strategies for monitoring pollutants and their impact on the environment
- demonstrate new monitoring systems and technologies by applying them to fulfill special monitoring needs of the Agency's operating programs

This report describes the 3-year airborne air-monitoring program conducted by the Las Vegas Laboratory as part of the Regional Air Pollution Study in the St. Louis, Missouri/Illinois, metropolitan area, 1974 to 1976. The data, obtained above the urban area using Las Vegas Laboratory helicopters, should be of great value to the air pollution modelers and analysts who are concerned with the transport and dispersion of pollutants through the atmosphere. The Air Quality Branch of the Monitoring Operations Division of this Laboratory should be contacted for further information pertaining to this report.

George B. Morgan
Director
Environmental Monitoring and Support Laboratory
Las Vegas, Nevada

PREFACE

This report describing the airborne measurement program carried out as part of the Regional Air Pollution Study (RAPS) is intended to give model developers and model users an insight into the vertical distribution of pollution over the St. Louis, Missouri/Illinois, metropolitan area. For those who seek only a general knowledge of the RAPS helicopter program, the main body of the report contains brief descriptions of the measurement program and examples of the results.

Seven field studies were performed:

Mission	Periods of Measurement
Summer 1974	July 15, 1974 - August 30, 1974
Fall 1974	November 3, 1974 - December 6, 1974
Winter 1975	February 10, 1975 - March 14, 1975
Summer 1975	July 14, 1975 - August 15, 1975
Winter 1976	Feburary 16, 1976 - March 19, 1976
Summer 1976	July 12, 1976 - August 13, 1976
Fall 1976	October 25, 1976 - November 19, 1976

The main text of the report shows how the airborne measurements for these studies were made. In conjunction with surface measurements taken at Regional Air Monitoring System stations and meteorological data taken from the RAPS Upper Air Sounding Network, these data can be used to construct a 3-dimensional picture of the pollution distribution over the St. Louis, Missouri/Illinois, metropolitan area. Appendices augment the text and are included primarily for the modelers who will use these data. For example, Section 3 of the text discusses use of a pressure transducer to measure the altitude of the helicopter in flight, whereas Appendix A presents the detailed equations which relate measured pressure and temperature to altitude and the results of the altimeter calibrations.

A logical way for the modeler to approach the RAPS helicopter data base is to decide on some prior basis which days are of interest for modeling--for example, a subset of days in which pollution levels were high, winds were from a particular direction, and the atmosphere was stable. The report answers the specific questions:

Were the helicopters flying on the days of interest?

Which flight patterns were flown?

At what times of day were measurements taken?

Which instruments were in operation?

The collected data described in this report have been compiled on magnetic tape and deposited within the RAPS data bank maintained by the U.S. Environmental Protection Agency at Research Triangle Park, North Carolina. Those who wish to use these data should contact that office:

U.S. Environmental Protection Agency,
Research Triangle Park,
North Carolina 27711

The English units of measure used in this report are those established at the beginning of the study and correspond to the units presented on the data tapes. See Appendix F for conversion to metric equivalents.

ABSTRACT

This research program was initiated with the overall objective of providing measurement of air pollution and temperature gradient over the St. Louis, Missouri/Illinois, metropolitan area to complement surface measurements of air pollution by the Regional Air Monitoring System (RAMS) of the Regional Air Pollution Study (RAPS). These measurements aloft were made by instrumented helicopters provided with a data acquisition system for recording all aerometric data, together with navigational data and supplementary status information.

These data obtained during the 3-year period, 1974 to 1976, are intended to provide insight into the transport and diffusion processes for air pollutants and to enable model developers and other users to evaluate and analyze the suitability of simulation models for prediction and decision-making.

This report describes in detail the helicopter data collection program and catalogs the missions flown by date, time, flight pattern and purpose. These data, collected on magnetic tape, are deposited in the RAPS data bank maintained by the U.S. Environmental Protection Agency. Sufficient examples are provided, with figures and tables, to enable the prospective user of these data to understand the measurements and their limitations, and so facilitate usage of the data.

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LIST OF ABBREVIATIONS

a.c. = alternating current
AGL = above ground level
BDCS = Bendix Dynamic Calibration System
BCD = binary coded decimal
bpi = bits per inch
B_{scat} = scattering coefficient
CH_4 = methane
CIC = Computer Instruments Corp.
CO = carbon monoxide
d.c. = direct current
DAS = data acquisition system
DDC = Data Device Corporation
DME = distance measuring equipment
FAA = Federal Aviation Administration
FID = flame ionization detector
GPT = gas phase titration
h = hour(s)
H_2S = hydrogen sulfide
Hg = mercury
i.d. = inside diameter
IBM = International Business Machines
km = kilometer(s)
kpa = kilopascals
l/min = liters per minute
m = meter(s)
m/s = meters per second
mb = millibar
Meloy = Meloy Laboratories, Inc.
MFE = MFE Corporation
min = minute(s)
ML = Monitor Labs, Inc.
mm = millimeter(s)
MRI = Meteorology Research, Inc.
MSA = Mine Safety Appliances Co.
MSL = mean sea level
NBKI = neutral buffered potassium iodide
NBS = National Bureau of Standards
NMCH = non-methane hydrocarbon
nmi = nautical mile(s)
NO = nitric oxide
NO_2 = nitrogen dioxide
NO_x = nitrogen oxide
O_3 = ozone
OAT = outside ambient temperature
PAN = peroxyacetyl nitrate
ppm = parts per million
RAMS = Regional Air Monitoring System
RAPS Regional Air Pollution Study
s = second(s)
SRM = Standard Reference Material
SO_2 = sulfur dioxide
TECO = ThermoElectron Corporation
THC = total hydrocarbons
V = volt(s)
Va.c. = volts, alternating current
Vd.c. = volts, direct current
VFR = visual flight rules
VHF = very high frequency
VOR = VHF omni-ranging
µm = micrometer(s)
$\mu g/m^3$ = micrograms per cubic meter

1. INTRODUCTION

The Regional Air Pollution Study (RAPS) was the largest, most comprehensive air pollution investigation ever undertaken by the U.S. Environmental Protection Agency. It was conducted in the St. Louis, Missouri/Illinois metropolitan area, as representative of other urban areas and because a broad research and data base existed from previous studies in the region. In addition, the geography, topography, and source mix of the area were relatively easy to describe in model development. The aim of the study was to produce enough information on all the processes that determine the concentrations of air pollutants so that they could be described in a system of mathematical models encompassing entire metropolitan areas.

A model, in this context, is a mathematical portrayal of the interacting conditions and processes that represent environmental quality in a given geographical area. A validated air simulation model is a useful and often effective cost-saving tool for air quality management by air pollution control agencies. Model development involves evaluation of the accuracy of existing and future models in estimating ambient air pollution concentrations within metropolitan regions, using the best available data on sources, meteorological variables, and actual measured ambient concentrations. Model development was a primary purpose of the RAPS. Hopefully, it will also include the refinement of models to incorporate new knowledge about the transport, transformation, and deposition of air pollutants (Thompson and Kopczynski, 1975).

The RAPS encompassed several different types of activities. Applicable models have been developed and inventoried, and these models are being readied to accept data for testing. The 25-station Regional Air Monitoring System (RAMS) collected ground-level data for model validation over a circular area 80 kilometers (km) in diameter in the St. Louis area. The stations were instrumented to measure sulfur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), ozone (O_3), hydrocarbons, aerosols, wind speed, wind direction, temperature, dew point and turbulence (Myers and Reagan, 1975). Winds and temperatures aloft were observed through pilot balloon (pibal) and radiosonde measurements at different sites in the study area (Zegel, 1976).

A vital part of the RAPS activities was the airborne measurement program conducted by the Environmental Monitoring and Support Laboratory-Las Vegas. Two specially instrumented helicopters were used in collecting data to complement the data being collected from fixed and mobile monitoring equipment on the ground and from monitoring equipment installed on other aerial platforms.

Intensive study periods were conducted during the summer, fall and winter seasons, from the summer of 1974 through the fall of 1976, as shown on page iv. During each period, the frequency of the routine measurements was increased and a variety of special experiments was conducted. Among these experiments were boundary layer studies, energy budget studies, and special plume studies. The intensive study periods also included measurements programs by rotary and fixed-wing aircraft.

As originally envisioned in early RAPS planning, the most ambitious of the regional air quality simulation models to be developed and tested against the RAPS data base would describe air quality, chemistry, and dispersion in an Eulerian system by superimposing a 3-dimensional grid over the St. Louis metropolitan area and solving the continuity equation for pollutants of interest across the grid.

Such models perform a mass balance on each grid cell, accounting for pollutant mass flow into and out of the cell, and the mass of pollutant created or destroyed within each cell. In planning the RAPS helicopter measurement program, the model area was assumed to be 40 km on a side and approximately centered on tne Jefferson Memorial Arch. The area would extend vertically to the top of the mixed layer, estimated in early 1974 to vary from as little as 50 to 100 meters (m) above ground level (AGL) in the winter predawn hours to more than 1,000 m AGL in summer midafternoons. Minimum horizontal grid cell dimensions were expected to be 1 km on a side, with the vertical dimension divided into a number of layers which would depend on the desired degree of model resolution.

One presently operable Eulerian photochemical model, developed by Roberts et al. (1973), divides the mixing depth into ten layers. A cell of the RAPS grid, assuming this resolution with a mixed layer depth of 300 m would measure 1 km by 1 km by 30 m. The Eulerian model(s) would then yield pollutant concentrations averaged over the volume of the cell, and averaged over a time period probably not less than 1 hour.

The necessary input data for all such models include pollutant emissions and meteorology. Presently available Eulerian models require the additional input of topography and wind fields, though other models under development will possess the capability of calculating wind fields from synoptic meteorology (Johnson, 1972). Calculations in all of the models will begin from some known or assumed set of initial conditions, and in all models some known or assumed set of boundary conditions at the edges of the modeling grid will be used. The airborne monitoring program was envisioned in early RAPS planning, primarily for the purpose of establishing sets of 3-dimensional initial and boundary conditions, and as a vertical extension of the information being collected on the ground by the RAMS. Early planning envisioned year-round airborne platform measurements. The airborne platforms were also to provide special measurements for plume chemistry studies, studies of the spatial variability of pollutants over distances of a few kilometers, and support of urban energy budget studies.

The following section of this report describes the helicopter platforms chosen for the RAPS program, their air quality instrumentation and the results of the measurement program.

2. HELICOPTER MEASUREMENT PLATFORM

The requirements for the RAPS airborne measurement platforms were originally defined as follows:

1. unrestricted operation at low altitudes over urban areas
2. instrument and crew payload of about 1,000 kilograms
3. continuously available electric power of about 4 kilowatts
4. operating range of at least 2 hours, preferably 3 or more
5. reasonable operating costs.

Aircraft availability, logistics, and economics soon limited the scope of the RAPS airborne measurement program. The only platforms closely satisfying these criteria were the Bell 212 (military designation UH1N) and the Sikorsky S-58T (military designation H-34T). The purchase price of the Bell 212 (about $750,000 in 1974) was beyond the scope of the RAPS budget, as was the cost of converting Sikorsky S-58's to S-58T's by adding a twin-turbine power pack (about $400,000 in 1974). Lease costs for the Bell 212 were about $20,000/month plus $200/flight hour. Military UN1N's were unavailable. However, three single-engine military Sikorsky S-58's were available and met all RAPS requirements except that for unrestricted low-altitude urban operation.

Three Sikorsky S-58 helicopters were delivered by the EPA to a contractor in Los Angeles for modification for air quality monitoring. The first two were delivered April 15 and April 19, 1974, respectively. The third was delivered May 30, 1974. The three major tasks to modify the military aircraft to sampling platforms were:

1. design and drawings

2. fabrication and assembly

3. installation and checkout.

Completion and delivery was scheduled for June 17 for the first two systems and July 5 for the third.

To make the aircraft airworthy, the contractor assisted EPA personnel in routine air-frame and engine inspections and maintenance on the three helicopters. Repairs to structural and skin sections were made to helicopter No. 3. This and other unanticipated work, as well as a basic underestimate of the planned work, caused delivery to be delayed until July 17, August 2, and September 9 for the three ships respectively. The final cost of modification was on the order of $160,000.

The Federal Aviation Administration (FAA) permitted use of single-engine helicopters in St. Louis at altitudes below 150 m AGL over locations where they could autorotate to a safe landing in the event of engine failure. Accordingly, the environs of the RAMS station sites were inspected from the air to find a nearby location for safe autorotations. FAA approval of these sites was obtained, and a helicopter data collection plan was devised to determine the initial and boundary conditions of the modeling grid. The plan consisted of vertical soundings over selected RAMS stations or nearby open areas. The soundings typically began at altitudes above the inversion base and extended downward to 60 m AGL.

3. HELICOPTER INSTRUMENTATION SYSTEM

Most airborne air quality measurement systems, whether in helicopters or in fixed-wing aircraft, have certain elements in common:

1. air-sampling manifolds designed to transport undisturbed air into the aircraft and to reduce its velocity
2. analyzers for continuous measurement of gaseous pollutants and certain aerosol characteristics
3. mass air-sampling devices to collect particulate matter on filters for later ground-based laboratory analysis
4. grab-sampling devices to collect air samples for analysis by gas chromatography to determine hydrocarbon and halocarbon concentrations
5. aircraft navigation system and clocks to provide continuous and accurate records of time and position in 3 dimensions
6. digital data-logging devices to record all of this information on magnetic tape for later computer processing.

One of the three Sikorsky S-58 helicopters with its side-mounted air intake probes and its temperature sensor is shown in Figure 1. Figure 2 is a block diagram of the plumbing between the probes and the instruments. Table 1 lists the analyzers and instrumentation which comprised the air quality measurement systems aboard the helicopters. The instrumentation complement changed somewhat during the course of the RAPS, and these changes are discussed in detail below. Figure 3 is a block diagram of the instruments and data system.

The RAPS helicopter air quality systems continuously measured concentrations of the following pollutants: ozone (by chemiluminescent reaction with ethylene); nitric oxide and total oxides of nitrogen (by catalytic reduction of nitrogen dioxide to nitric oxide and subsequent chemiluminescent reaction with ozone); carbon monoxide (by a technique utilizing dual-isotope fluorescence non-dispersive infrared detection); and sulfur dioxide (by flame photometry or by pulsed fluorescence). To measure light-scattering from aerosols, the helicopter installation also included an integrating nephelometer which utilized a preheater to minimize the influence of water vapor. Aerosol-size distributions over the range of 0.3 to 3 micrometers (μm) were continuously measured on certain flights by an optical particle-size counter. Ambient air temperature and dew point were also continuously recorded. Grab samples of air were collected in Tedlar bags for subsequent laboratory analyses by gas chromatography for specific hydrocarbon compounds. Particulates were collected on filter media for laboratory analyses to determine concentrations of sulfates, heavy metals, toxic

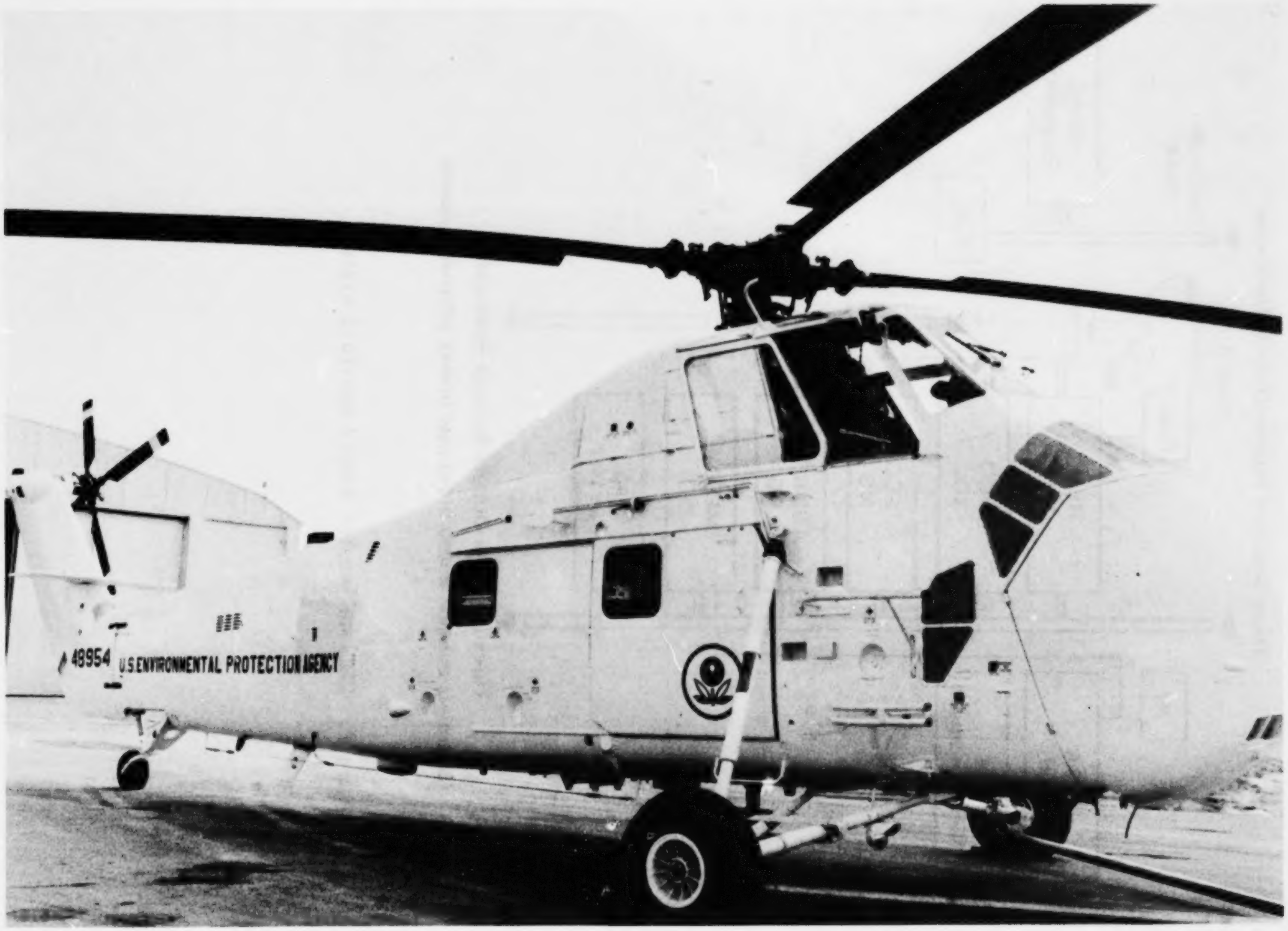
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Figure 1. RAPS S-58 helicopter.

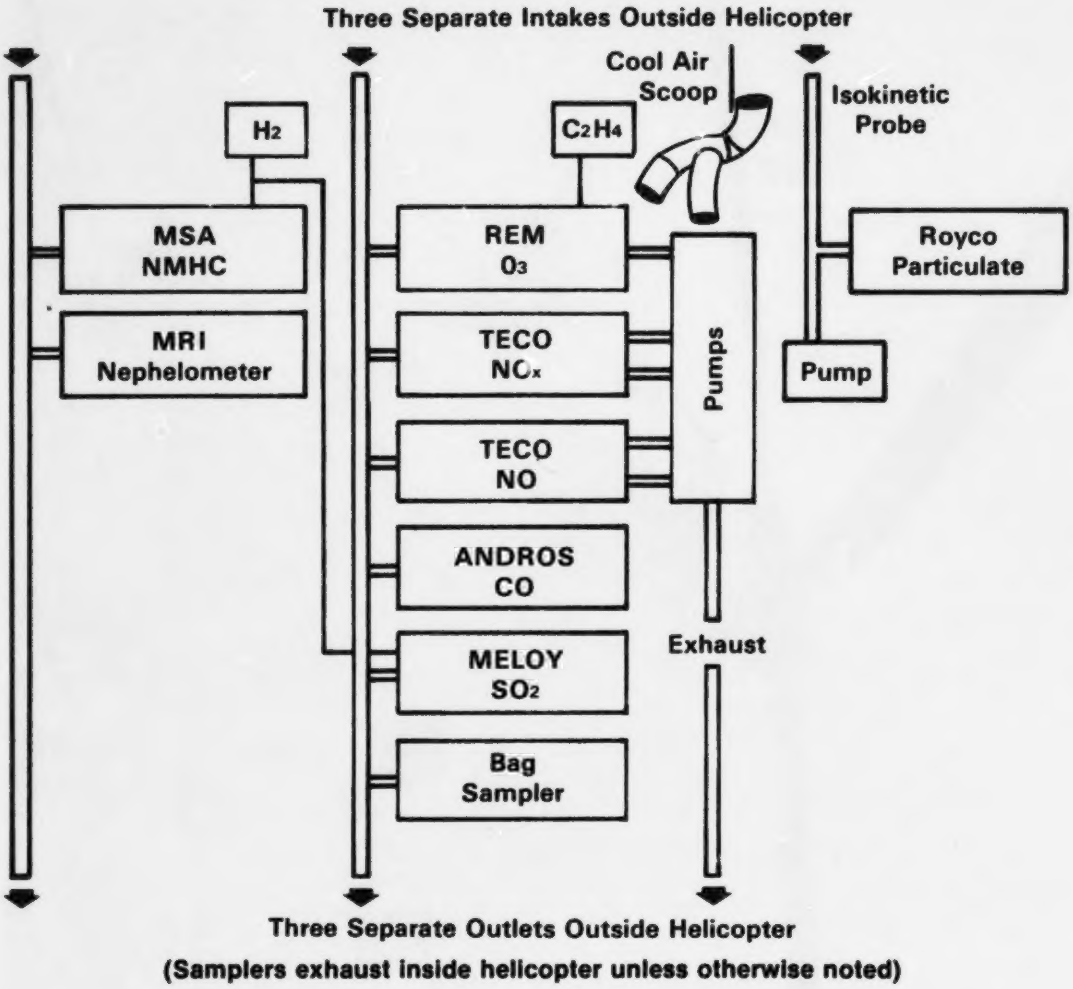
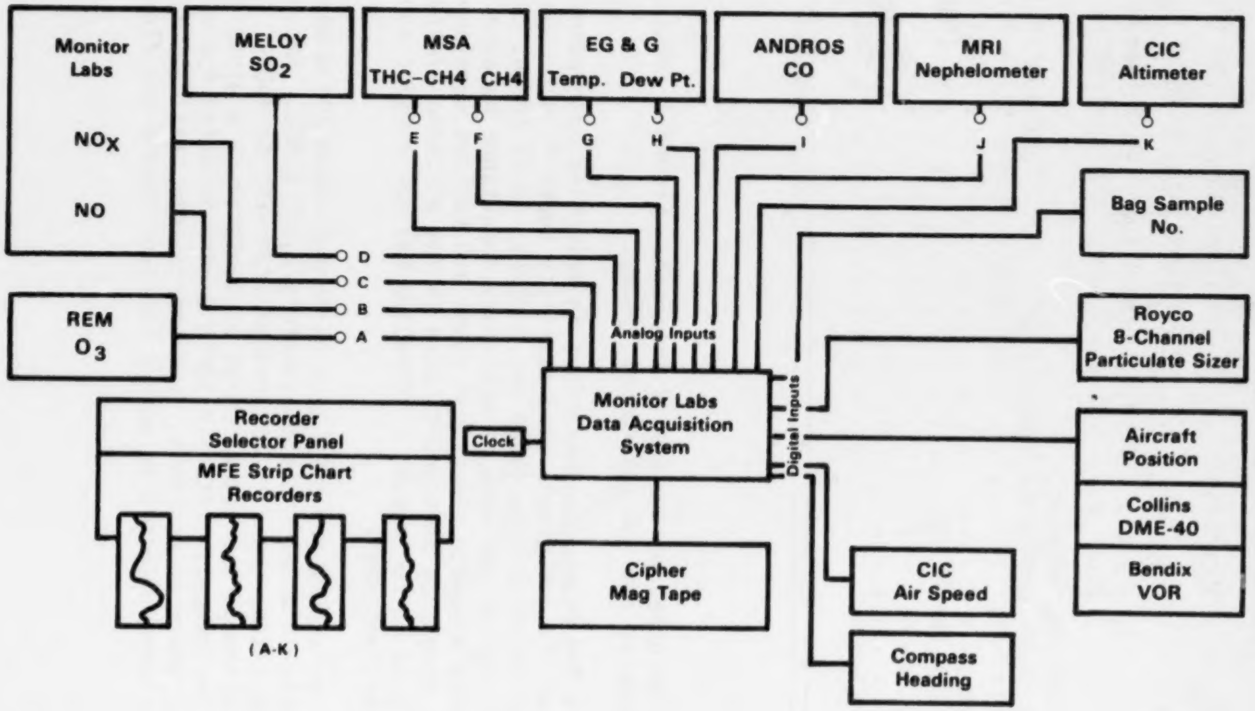

Three Separate Intakes Outside Helicopter
Cool Air Scoop
Isokinetic Probe
H_2
C_2H_4
MSA NMHC
MRI Nephelometer
REM O_3
TECO NO_x
TECO NO
ANDROS CO
MELOY SO_2
Bag Sampler
Pumps
Royco Particulate
Pump
Exhaust
Three Separate Outlets Outside Helicopter
(Samplers exhaust inside helicopter unless otherwise noted)

Figure 2. RAPS helicopter sample manifold system.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CIC
Altimeter
E
F
G
H
I
J
K
Bag Sample No.
D
C
B
A
REM
O_3
Analog Inputs
Royco
8-Channel
Particulate Sizer
Monitor Labs
Data Acquisition
System
Digital Inputs
Recorder
Selector Panel
MFE Strip Chart
Recorders
Clock
Aircraft
Position
Collins
DME-40
Bendix
VOR
(A-K)
Cipher
Mag Tape
CIC
Air Speed
Compass
Heading

Figure 3. RAPS Helicopter data system.

TABLE 1. RAPS HELICOPTER INSTRUMENTATION

Parameter	Method and Instrument
NO, NO_x, (NO_2 by Subtraction)	Chemiluminescence ($NO + O_3$) (TECO 14B)
O_3	Chemiluminescence ($O_3 + C_2H_4$) (REM 612)
CO	Non-dispersive Infrared (Andros 7000)
SO_2	Flame Photometry (Meloy SA160)
Total Hydrocarbons, methane, (Non-Methane Hydrocarbons by Subtraction)	Flame Ionization (MSA 11-2)
Particles (Visibility)	Nephelometer (Light Scattering) (MRI 1550)
Particle Size	Optical (Royco 220)
Temperature and Dew Point	(Cambridge CS137)
Location	DME/VOR
Altitude	Barometric Pressure
Bag Samples (Tedlar)	Gas Chromatography

substances, or other parameters of interest. Figure 4 shows an interior view of the helicopter and the instrument system.

The most important considerations in selecting instruments for aerial monitoring of air pollutants were stability under flight conditions and shortness of response time (Mage and Noghrey, 1972) (Mage, 1975). Power requirements and weight were of secondary importance because suitable platforms with adequate electrical power and payload were available. Although vibrational stress on instruments used in any airborne platform is severe, and particularly so in helicopters, vibration was not a major contributor to instrument malfunctions.

Flight operations for RAPS were performed above 200 m mean sea level (MSL) (approximately 60 m AGL) to approximately 2,000 m MSL. Ambient operating temperatures inside the aircraft ranged from -20° to +50° C through the course of a year, although the actual range encountered in a given flight was much less. The instruments listed in Table 1 were selected for minimum altitude sensitivity; wherever possible, instruments with critical orifice or capillary flow control were selected to assure constant sample air flow.

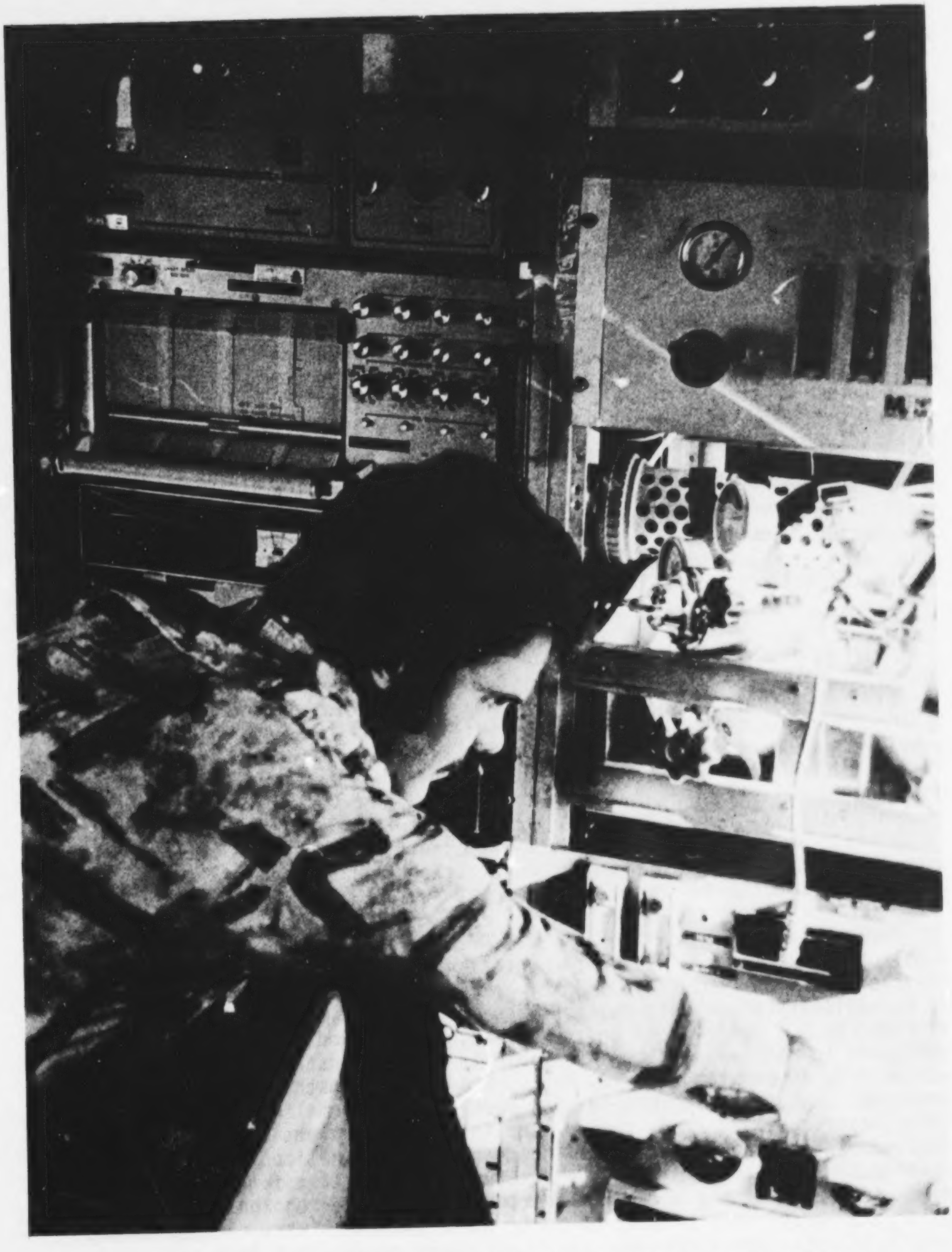


Figure 4. Interior view of RAPS helicopter instrument system.

INSTRUMENT SYSTEM DESIGN CONSIDERATIONS

Other design considerations for the helicopter instrument systems included position measurement capabilities, sampling manifold design, use of capacitors to compensate sample pump-motor inductive power factors, and power switching arrangements to permit continuous operation of helicopter instrumentation while on the ground.

Position of the helicopters in flight was determined by triangulation with two different air navigation beacons. Each helicopter carried two digital Distance Measuring Equipment (DME) systems, each tuned to an air navigation beacon. The distance to each beacon was determined to within ±0.1 nautical mile (nmi), and the VHF Omni-Ranging (VOR) bearing to one of the beacons was also recorded. The bearing was used to resolve a dual-position ambiguity resulting from triangulation. Aircraft indicated airspeed was determined and recorded to ±1 knot. Aircraft heading was determined to within ±1 degree via a synchro-to-digital converter attached to the magnetic compass. The relatively slow helicopter airspeed of 60 knots used on horizontal flight legs yielded a ratio of wind speed to indicated airspeed larger than is available with most fixed-wing aircraft. This ratio, together with the accurate position data from the DME/DME/VOR system, made possible a relatively accurate calculation of wind speed and direction. In comparison with simultaneous pibal data, the helicopters yielded wind speed measurements over 7-minute horizontal flight legs which agree to within 10 percent of the pibal wind data.

Helicopter intake probes and manifolds were made of 38-millimeter (mm) inside diameter (i.d.) stainless steel, and the probes and manifolds used for reactive pollutants (O_3, NO, NO_2, and SO_2) were lined with Kynar, a fluorocarbon plastic with properties similar to Teflon. All sample ducts and lines were made of Teflon tubing. Sample probes were located near the front of the helicopter's right side as shown in Figure 1, and the probes sampled undisturbed air during normal flight. At forward speeds greater than about 30 knots, the rotor wash trajectory strikes the fuselage well aft of the probe locations. To verify the rotor wash trajectory, flight tests were performed with the RAPS helicopters using ribbons attached at many points on the helicopter fuselage to indicate flow patterns.

Power distribution systems for the RAPS helicopters included provisions to supply power to air quality instrumentation in three ways: from aircraft 28-volt direct current (Vd.c.) power in flight; from 28-Vd.c. power provided by an auxiliary power unit while on the ground; and from 110-volt alternating current (Va.c.) power while on the ground. The ground power provisions were necessary to maintain instrument stability because instrument warm-up times varied from 30 minutes to a few hours, and because instrument calibrations sometimes changed after shutdown and restart. In normal operation during a RAPS intensive field study period, the instrument systems were operated continuously, 24 hours per day, without pause. The helicopter power distribution system permitted the instruments to be transferred from aircraft power to either of the alternate sources without interruption. Two 2,000-watt Unitron 28-Vd.c. to 110-Va.c, 60-hertz power inverters were carried aboard each helicopter for instrument in-flight power conversions from helicopter generators. To reduce current loading on these inverters, the inductive power factor of each instrument was measured, and capacitors were added to the power distribution system to compensate for these power factors. Use of power-factor compensation reduced the total current loading by approximately 9 amperes or about 1,000 volt-amps of reactive "power". Figure 5 is a block diagram of the power distribution system. To minimize ground loops and electrical noise, all equipment racks were electrically isolated from the air frame at the mountings, but all were tied to a common point through heavy grounding cables.

The following section describes the instrumentation chosen for the RAPS helicopter measurement system.

DESCRIPTION OF MEASUREMENT INSTRUMENTATION

Gaseous Pollutants

The gaseous pollutants, carbon monoxide (CO), NO, NO_x, O_3, SO_2, methane (CH_4) and total hydrocarbons (THC), were measured in real time by the helicopter system. Supplementing the continuous monitors, bag samples could be taken for subsequent analysis in the laboratory. All measurement methods were according to the techniques promulgated at that time in the Code of Federal Regulations or equivalent techniques, where available.

Carbon monoxide concentrations were measured with a Beckman/Andros Model 7000 analyzer. This analyzer quantified the concentrations by measuring the absorbence of infrared radiation by CO in the sample chamber utilizing the dual isotope fluorescence technique. The Model 7000 analyzer is designed to detect 0.1 parts per million (ppm) of CO and has as its lowest range of operation 0 to 20 ppm full-scale.

Both NO and NO_2 concentrations were measured by the same instrument. Two brands of instruments were used in the RAPS helicopters to measure oxides of nitrogen. Thermo Electron Corporation (TECO) Model 14B analyzers were used during the July-August and November-December 1974 RAPS field exercises, and Monitor Labs, Inc., (ML) Model 8440 analyzers were used during all other field exercises. Both analyzers monitor NO by measuring the light from the chemiluminescent reaction of NO with O_3. Both brands of analyzer monitor the NO_x concentrations by catalytically reducing NO_2 to NO and then measuring the total NO as NO_x. Because the TECO 14B analyzer could not measure NO and NO_x simultaneously, two TECO instruments were used in each helicopter system. The ML 8440 was able to measure NO and NO_x simultaneously and one ML8440 could replace two TECO's. The TECO 14B had as its lowest range of operation 0 to 0.20 ppm full-scale. The ML 8440 operated on a lowest range of 0 to 0.20 ppm full-scale.

Ozone concentrations were measured with a REM Model 612 monitor. The REM instrument monitors O_3 by measuring the light emitted by the chemiluminescent reaction of O_3 with ethylene gas. The lowest level of detection for the REM was 0.001 ppm, and the lowest range of operation was 0 to 0.20 ppm.

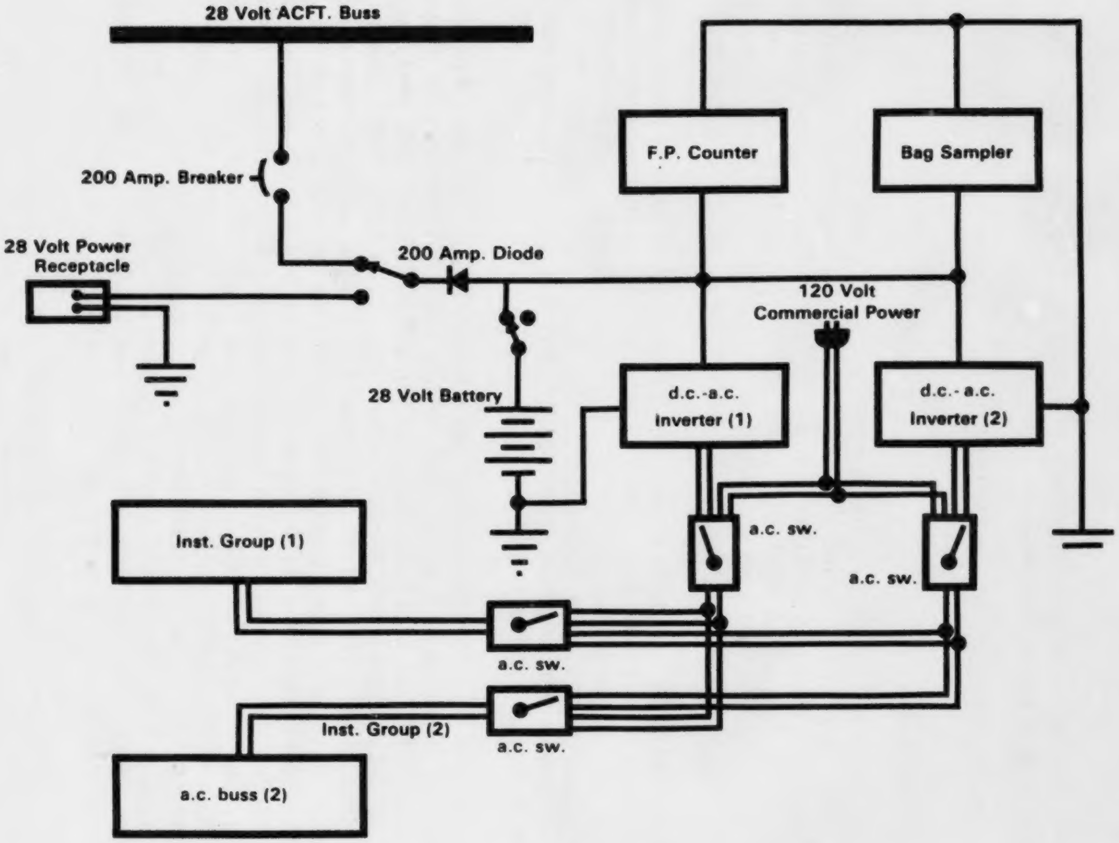

28 Volt ACFT. Buss
200 Amp. Breaker
28 Volt Power Receptacle
200 Amp. Diode
28 Volt Battery
F.P. Counter
Bag Sampler
120 Volt Commercial Power
d.c.-a.c. Inverter (1)
d.c.- a.c. Inverter (2)
a.c. sw.
a.c. sw.
Inst. Group (1)
a.c. sw.
Inst. Group (2)
a.c. sw.
a.c. buss (2)

Figure 5. RAPS Helicopter electrical system.

Concentrations of SO_2 (measured as total sulfur) were monitored with a Meloy Laboratories, Inc., (Meloy) Model SA-160 analyzer. SO_2 is monitored by measuring the light produced by a chemiluminescent sulfur species in a hyperventilated hydrogen flame (a flame photometric detector). Because this analyzer responds to almost all sulfur compounds and not just to SO_2, it is generally considered to be a "total-sulfur analyzer". The minimum detectable concentration of the SA-160 was 0.005 ppm.

Hydrocarbon concentrations (methane and total hydrocarbons) were measured with a Mine Safety Applicances Company (MSA) Model 11-2 monitor. In this instrument, the hydrocarbons are measured by means of a hydrogen flame ionization detector (FID). Total hydrocarbons (THC) are measured directly, while methane is measured on a separate flame after the air sample has passed through a stripper column that removes all other hydrocarbons. The lowest range of operation for the MSA analyzer for both THC and methane was 0 to 5.0 ppm full-scale.

Bag samples were collected in order that a more detailed compositional analysis might be done for the hydrocarbons. A bag sampler was designed to sequentially fill up to five Tedlar bags with ambient air. One of three flow rates, 28, 14, and 7 liters per minute (l/min), could be selected by a switch. A given flow setting also selected a fixed sampling time of 2, 4, or 8 minutes respectively to fill a 56-liter bag. All plumbing was stainless steel, including the three-way solenoid valves which controlled the flow to each bag. Valve seals were of Viton. Air was pumped into the bags by a small diaphragm pump which had been coated inside with Teflon. A prefilter cartridge of marble chips coated with manganese dioxide powder was put in the sample line to destroy O_3 and thus protect the hydrocarbons in the sample from oxidation. Care was taken to keep the bags out of direct sunlight during transport and storage. Bags used in sampling were supplied by the various investigators. Because sample analyses were performed by outside investigators as listed in Appendix E, no bag sample data are included in this report.

Particulate Pollutants

Particulate levels were also measured by the helicopter system. Continuous readings were taken of the light-scattering coefficient in the 0.1- to 1-μm range of particle-size distribution. Filter samples were taken to examine mass loading and chemical composition.

The particulate light-scattering coefficient was measured by a Meteorology Research Inc. (MRI) Model 1550 integrating nephelometer equipped with a preheater. The instrument makes continuous measurements of the visual quality of the ambient air. The atmospheric extinction coefficient due to the scattering of light by both gases and aerosols is determined. The instrument has a sensitivity range of 10^{-5} to 10^{-2} reciprocal meters (m^{-1}); this corresponds approximately to a mass loading range of 0 to 3,800 micrograms per cubic meter ($\mu g/m^3$).

Particle-size distribution was provided by a Royco Model 220 aerosol-particle monitor. This monitor was coupled to a multichannel analyzer which scaled particle counts in eight size ranges. The Royco projects a beam of light through the air sample and measures the 90-degree scatter with a photomultiplier tube. The size and frequency of the pulses are an indication of the size and number of the particles. The analyzer detects particles larger than 0.5 µm in aerodynamic diameter. The multichannel analyzer can be adjusted to a wide range of pulse sizes.

Special filter samples were taken with the helicopter system. An attempt was made to provide isokinetic flow at the sample intake by using a tapered, machined probe tip. A filter holder was built to accommodate 37-mm diameter filters. Flow rates available through this system were 28 or 65 l/min. Teflon 1-µm pore size filter media were used and analyzed for sulfates during some RAPS flights. The airmover was a Gelman carbon vane pump and flow was determined by measuring the pressure drop across the filter with a Magnehelic gauge. Filter analyses were performed by outside investigators as listed in Appendix E, and no filter analysis data are included in this report.

Temperature and Pressure (altitude)

Temperature and dew point were determined continuously with an EG&G Vapormate II using a Model CS137 thermometer-hygrometer probe. The air temperature was sensed with a thermistor located in the direct path of the moving air. Dew point was determined by a condensation hygrometer, a thermoelectrically cooled mirror with an optical system which detects fogging of the mirror surface. The temperature sensor operated within the range of -40° to +49° C, with a temperature accuracy of ±0.8° C.

The dew point sensor operated from -40° to +40° C. The listed accuracy of the dew point sensor varies with temperature range; accuracy is ±0.8° C in the range 0° to 49° C, ±1.1° C in the range -29° to 0° C, and ±1.7° in the range -40° to -29° C.

Pressure altitude was measured automatically by a Computer Instruments Corporation (CIC) Model 8000 electric altimeter. This device was plumbed into the aircraft static pressure line. Changes in static pressure are detected by a diaphragm which is mechanically linked to a potentiometer. Excitation is provided by aircraft 28 Vd.c., and output is nearly linear with altitude (based on the U.S. Standard Atmosphere model). According to the manufacturer, the range is from 305 m below sea level to 9,150 m ASL. Accuracy, according to CIC, is ±12 m in the range of altitudes flown over St. Louis. The calibration data are given in Appendix A. The equations to correct the altitude for deviations from the standard atmosphere model, caused by synoptic pressure and temperature variations, are also listed in Appendix A.

Avionics

Avionics equipment were incorporated into the helicopter air monitoring system to provide data which were used to calculate position and wind fields, as described below.

True position was determined by three instruments which are not part of the normal aircraft navigation equipment, two Collins DME-40 transceivers and one Bendix RVA-33A VOR receiver. The DME (distance measuring equipment) transceivers measure line-of-sight distances from two VORTAC air navigation stations on the ground.

The VOR (VHF-omni-ranging) measures the bearing in degrees from one of the stations. Position was determined by triangulation of the two DME distances. The VOR bearing resolved which of the two possible DME intersects was the true position. Accuracy of the DME-40 was ±0.1 nautical mile (185 m) within line-of-sight range. The accuracy of the VOR was about ±5° above 500 m AGL and within 16 km of the VORTAC station. At lower altitudes, radio beacon reception was less reliable, and resolution of the VOR bearing became as poor as ±20° near the ground.

Digital data from the DME and VOR instruments were fed directly into the data acquisition system as nautical miles and degrees respectively. Compass heading and indicated airspeed were also recorded. A Data Device Corporation (DDC) Model 4700 synchro-to-digital converter digitized the three synchro voltages from the ship's compass and output in real time the heading in degrees. The airspeed was measured with a CIC Model 7100 differential pressure transducer which was plumbed into the helicopter pitot and static pressure lines. Accuracy of the compass heading was ±1° and that of the airspeed was ±1 knot.

These data could be used to plot the helicopter course from a known position as if there were no wind effect on the helicopter. The vector distance (L) from the computed position to the true position over a period of time (Δt) is the distance the helicopter has been blown off course. The average wind speed is therefore $\bar{u} = L/\Delta t$, and the average wind direction is in the direction of the vector L. Because the accuracy of the true helicopter position was ±0.2 nautical mile by DME measurements, it was necessary to fly about 10 minutes at 60 knots (true airspeed) with a 12-knot wind to obtain an accuracy on the order of ±10% for L.

Data Processing

The data logger at the center of the helicopter system was an ML Model 7200 R-D2 with digital clock modules C1-C4. The 7200 was equipped to input digital and analog signals, and it was interfaced to a Cipher Model 70 digital magnetic tape recorder.

Thumbwheel switches on the ML 7200 allowed codes to be entered for such things as range setting for the various air quality instruments and the Julian date. The normal scan rate during the RAPS missions was one 132-character record every 5 seconds. This record was output on magnetic tape in IBM-compatible 7-track binary coded decimal (BCD) code with a packing density of 200 bits per inch (bpi) (1 inch = 2.54 centimeters). This relatively low packing density was required to overcome vibration interferences.

Figure 3 is a block diagram of the total data system. All of the analog signals from the various air quality instruments were input first to a recorder selector panel. This allowed selected signals to be recorded on any of four channels of an MFE Corporation (MFE) Model M24CRAHA strip chart recorder. Although the recorder provided backup to the tape deck for four of the parameters, its primary use was for calibration and in-flight display.

All of the instruments discussed above had corrections that needed to be accounted for before the collected data were put into final form. The following section discusses the effects of pressure, temperature, humidity and other interferences. In addition, the lag and response times of the instruments are discussed and their corrections are outlined.

4. QUALITY ASSURANCE OF DATA

The quality assurance of the data obtained by the RAPS helicopters was given high priority in all stages of mission planning and execution. With the choice of the unpressurized S-58 helicopter for the airborne platform, the difference between the measurement conditions and calibration conditions became a major concern. Almost all of the pollution monitors which met the requirements of the Code of Federal Regulations were designed not for aircraft operation, but for ambient operation in a controlled temperature environment within a small range of ambient pressure corresponding to the normal synoptic variations. In order to assure the validity of the measurements made in flight, a comprehensive quality assurance program was implemented which covered the following five component segments:

1. Calibration Standards
2. Calibration Procedures and Techniques
3. Instrumental Corrections
4. Instrument Response Time Corrections
5. Independent Interlaboratory Audits

CALIBRATION STANDARDS

All measurements made by the RAPS helicopters were designed to conform to current Code of Federal Regulations Reference Methods and, where possible, all calibration standards were Standard Reference Materials (SRM) traceable to the National Bureau of Standards (NBS). The policy of the RAPS helicopter group was to prepare a secondary field standard and analyze it relative to an NBS primary standard. The NBS standard was kept in Las Vegas and the secondary standard was used daily in the field calibrations. This procedure was designed to prevent the accidental loss of the primary calibration standards through leakage during routine use and also to save on costs. The standards used are described below by pollutant.

Carbon Monoxide (CO)

The CO primary standard was an NBS SRM mixture of CO and nitrogen contained in an aluminum cylinder. The secondary standards were CO-ultrapure air mixtures prepared by Scott-Marin in aluminum cylinders to a nominal concentration of 15 ppm.

Oxides of Nitrogen (NO and NO_2)

The initial secondary NO standard was analyzed during 1973 to be 81 ppm by gas phase titration (GPT) (Rehme, 1976), as referenced to the Code of Federal

Regulations neutral buffered potassium iodide (NBKI) method for O_3 analysis. When the cylinder was used in St. Louis during the Summer RAPS 1974 study, it was analyzed to be 77.5 ppm in reference to a RAMS station secondary NO standard. During the Fall RAPS 1974 mission, the cylinder was again compared to NBKI by GPT and was analyzed at 72 ppm. When an NBS-certified NO-N_2 mixture was received in the Spring of 1975, the cylinder was again analyzed to be 72 ppm.

The RAPS helicopter field standard was recertified to a new value close to the RAMS measured value, and all data obtained previous to this audit were corrected for the change in the span factor. All other NO cylinder standardizations had very stable and reproducible results.

The NO standard was also related to the ozone standard through the GPT technique as discussed in the following section on ozone. During the period in 1974 when the NBS NO cylinder was on order, the GPT technique was used to check the NO cylinder values and to perform calibrations.

Ozone (O_3)

No NBS reference materials are available for O_3 calibrations. The Code of Federal Regulations Reference Method for O_3 calibration at that time used the oxidation of an NBKI solution as the calibration principle. In the spring of 1974, the O_3 calibrations were being performed with a Dasibi 1002-AH O_3 analyzer as a secondary standard. This monitor, which demonstrated long-term stability, was calibrated by the Code of Federal Regulations NBKI Reference Method for O_3. This secondary reference Dasibi was also used to calibrate the NO cylinders by GPT; therefore, the O_3 and NO field standards were referenced either directly or indirectly to the Code of Federal Regulations Reference Method for O_3. This method of O_3 calibration was used until June of 1975. At that time an NBS NO-in-N_2 cylinder was received which allowed all secondary NO cylinders to be cross-compared directly to the NBS NO-in-N_2 cylinder. During this same period, the accuracy of the NBKI ozone reference method came under close scrutiny and testing by the EPA. The Dasibi O_3 monitor, which had been stable for nearly a year, developed electronic problems.

All of these developments required that an O_3 calibration be performed by GPT referenced indirectly to an NBS cylinder of NO-in-N_2 as the primary reference material. The O_3 calibration was performed daily by a GPT on the NO-NO_x analyzer using the secondary standard of NO-in-N_2.

Whenever the Dasibi O_3 analyzer was repaired and found to be functioning properly, a GPT would be performed directly with an NBS NO-in-N_2 cylinder. Once calibrated, the Dasibi would be taken to the field as the secondary reference for O_3 calibration. When the Dasibi was used as the secondary reference for O_3, it would be referenced periodically to a GPT on the NO-NO_x monitor using the secondary standard of NO-in-N_2, as referenced to an NBS NO-in-N_2.

Sulfur Dioxide (SO_2)

The SO_2 calibrations were performed with NBS-certified permeation tubes. SO_2 permeates through the Teflon wall of the tube at a known rate which is a function of the tube temperature. The permeation tubes were maintained at a constant temperature which was measured with a certified thermometer. Near the end of the warranted lifetime of the permeation tube, the tube was compared to a newly purchased NBS permeation tube prior to replacement to ensure equivalence between them.

Methane (CH_4) and Total Hydrocarbons (THC)

Methane and non-methane standards at low ppm concentrations were a problem for this study. Because NBS methane standards were out of stock at the beginning of the program, commercially prepared standards were used, which were found to be unstable. This problem was solved with the use of Scott-Marin cylinders of methane in air which proved to be stable. Although an NBS standard was not available directly, an independent certification was available by independent audits discussed later in this section.

Temperature

The temperature probes used in the initial studies, #627 and #629, were calibrated against an NBS-traceable Rosemount platinum thermometer in the range -10° to +40° C. The temperature data were fit by the least squares technique to a cubic equation with voltage as the independent variable. The maximum difference between the corrected data and any calibration point was 0.5° C. These corrections were made for the first five field studies.

The thermoelectric circuits of the first two temperature probes failed after the Winter RAPS 1976 mission and were replaced with new EG&G Vapormate II probes, #803 and #804. The temperature probes #803 and #804 were calibrated against an NBS-traceable Rosemount quartz crystal thermometer between -10° and +40° C at 5° C intervals. The temperature data were again fit by the least squares technique to a cubic equation with voltage as the independent variable. The maximum difference between the corrected data and any calibration point was 0.2° C. These corrections were made for the last two field studies. The calibration data for all four probes are given in Appendix A.

CALIBRATION PROCEDURES AND TECHNIQUES

Due to the extreme range of environmental conditions encountered in air quality monitoring from a helicopter platform, calibrations were required on a daily basis. For most calibrations in the RAPS program, the helicopters were parked in the hangar facilities. This was necessary to keep the instruments at reasonable temperatures and to provide thermal stability for the Bendix Dynamic Calibration System (BDCS). The BDCS must be kept in a given temperature range to allow the permeation tube oven to equilibrate at the desired temperature and to produce stable outputs and flows from the O_3 generator. The BDCS was operated with a Bendix heatless air dryer and either an MSA catalytic oxidizer or an Aadco pure air generator. The latter was used during the last four missions. These systems provided the zero-grade dilution air used in all calibrations of the O_3, oxides of nitrogen, SO_2, and CO instruments. The zero air also was used to establish the zero input response of the O_3 and oxides of nitrogen instrumentation.

Each calibration was performed in the following standard format, except for the first week or two of operation in the Summer RAPS 1974 project. The first item to be performed immediately after flight was the post-calibration zero. Without any monitor adjustment, zero air was sampled from the pure air generator. After equilibrium was achieved, the zero value from the monitor was recorded. Following this procedure, the air quality monitor was adjusted to zero and this pre-calibration zero was recorded. Following the zero adjustment, a known concentration of pollutant gas was introduced to the monitor. This span gas was formed in the BDCS by diluting the output of either a high concentration gas cylinder or permeation tube with zero air. With no span adjustment and after equilibrium of the signal, a post-calibration span reading was recorded. Next, the air quality sensor was adjusted to the appropriate signal level corresponding to the known input, and this value was recorded. This calibration sequence is based on the fact that a zero value adjustment of a given amount will directly affect the span value by the same amount. However, adjustment of a span value will not influence the zero value that has been pre-established. This method was applied for all SO_2, O_3, oxides of nitrogen, and CO instrumentation. The sequence was also applied to the nephelometer calibrations; however, in this particular monitor, span adjustments do affect zero values, and a re-zero was necessary.

Quality controls were performed frequently in many aspects of the RAPS helicopter operations. On a biweekly basis, multipoint calibrations were performed. The calibrations were implemented within the first week operation, midway through the project, and during the last week of the intensive studies. Zero-air tests were performed on the same schedule. Internal zeroes of the SO_2 analyzers and CO analyzers were compared to the Aadco pure air generator or the Bendix heatless air dryer and MSA catalytic oxidizer. Comparisons also were made between the in-flight zero-grade air (Linde or Matheson zero-grade air) and the Aadco pure air generator or the Bendix heatless air dryer and MSA catalytic oxidizer. These tests produced very favorable results for O_3 and SO_2, and oxides of nitrogen. A few problems occurred in the CO comparisons. A higher zero reading occasionally occured when sampling air from the Aadco pure air generator than when using air from the internal zero air scrubber of the CO monitor itself. The source of the problem is believed to be the difference in CO_2 background between each of the zero-air sources. The NO_x-NO converter efficiencies were tested weekly, at a minimum, and when gas phase titration was used for O_3 calibrations, the converter efficiency was checked on a daily basis.

All flows were calibrated on the BDCS at least once a week, but any problems incurred with the BDCS required that calibration of flows be made more frequently.

During the first three intensive studies (Summer RAPS 1974, Fall RAPS 1974, and Winter RAPS 1975), the flowmeters used were certified only to about

5% accuracy. During the last four missions, an NBS-traceable Teledyne-Hastings Miniflo Calibrator was used for flow measurements. This allowed a ±2% accuracy for flow measurement. This accuracy with an approximate ±2% accuracy for field standards gave a calibration error of ±4%; however, with the flows measured only once a week, the error could be as great as ±8% of the input value.

Primary calibrations of the MRI nephelometer were done in the field. The first primary calibration was performed immediately after set-up and again during the third week of the operation. This absolute calibration required two data points, the scattering coefficients for pure air and for pure Freon 12. The nephelometer was checked daily with an electronic test and zeroed and spanned according to the instruction manual.

Throughout the RAPS project the analysis of methane and non-methane hydrocarbons remained a difficult task. Two key problems restrained the collection of hydrocarbon data. The first problem was that of accurate standards for calibration described previously in section 4. The second problem was that of the MSA hydrocarbon analyzer catalyst stability. It was finally resolved that, because of frequent contamination (possibly phosphate), the catalysts (hopcalite) within the MSA were not reliable. Also, since the MSA hydrocarbon analyzer is much like a gas chromatograph, pronounced temperature fluctuations also become a problem. The catalyst problem was resolved by using hydrocarbon-free air from a cylinder rather than relying on the catalyst to supply hydrocarbon-free air to the flame.

After reviewing the problems encountered with the MSA analyzer and standards, it was determined that the hydrocarbon data were not defensible. All hydrocarbon data have been removed from the helicopter data base.

All Royco calibrations were performed with polystyrene latex beads manufactured by Dow Corning Corporation using a calibration system fabricated by the Las Vegas Laboratory's helicopter team. The Royco calibrations were performed each evening prior to a scheduled Royco flight.

During the first three missions when all flights were based at Scott Air Force Base, Illinois, the avionics were tested routinely with equipment loaned to the EPA by the Air Force. After deployment to Smartt Field, avionics test equipment had to be purchased. Until the avionics equipment was available, all avionics testing was done by test flights encircling a nearby VOR station, and by over-flights of landmarks to test the DME's. In-flight checks of the altimeter, VOR and DME data were also made routinely by comparison to the aircraft avionics which were completely independent systems.

INSTRUMENTAL CORRECTIONS

To assure the validity of the aerometric data, several operational tests were made on the instruments, both in the laboratory and in the field. A number of corrections and estimates of their magnitude are described. Of these, only zero drifts and span drifts were corrected for in the data base. The other corrections, such as response time and lag time, were of lesser magnitude and did not justify the reprocessing of the entire data set. However, these are described in sufficient detail that the data user can make the corrections if the individual application calls for it.

Density Correction - Pressure and Temperature

Air pollution monitors produce an output that is proportional to the number of molecules (i.e., mass) in the sampling chamber, not the ratio of pollutant volume to air volume (ppm). To provide true ratios of pollutant to air, adjustments need to be made to instrumented outputs to correct for density changes in the air resulting from pressure and temperature variations. Pollution measurements should be corrected to reference conditions at 25° C and 760 mm mercury (Hg) pressure. The temperature of the air sampled from the helicopters was measured and recorded continuously. The pressure of the air can be derived from the voltage output of the altimeter. Given the temperature and pressure of the sampled air, it is tempting to apply simple ideal gas-law relationships to correct these data. However, since individual instrument response may deviate measurably from the ideal gas-law relationships, chamber studies must be performed for each instrument.

Theoretically, instruments should be calibrated with a standard gas mixture at 25° C and 760 mm Hg pressure. The instrument, however, makes its readings at the temperature and pressure of the gas in the sampling chamber, not outside ambient levels. Many pollution monitors control the temperature and pressure in their sampling chambers. If these devices function properly, instrument readings can be automatically referenced to the density of air at standard reference conditions. Those instruments that have temperature and pressure control mechanisms, however, were not designed to operate within the extremes encountered in operating the instruments in an unpressurized aircraft.

Also, atmospheric density changes are not the only effects caused by pressure and temperature changes. Temperature effects may cause electronic components to behave differently; pressure fluctuations may cause changes in flow rates that will affect instrument response; and temperature and pressure may affect the principle of detection (for example, infrared absorption peaks broaden as temperature and pressure increases). Because of these uncertainties in the data caused by pressure and temperature fluctuation, environmental chamber studies were undertaken to qualify the error in instrument output as a function of temperature and pressure and, if possible, to experimentally derive equations to correct these data.

Span and Zero Drift Corrections

Basically, two approaches were taken to isolate and identify environmentally caused detrimental effects to the signal output of the instruments:

1. Experiments were designed to test in situ instrument response under actual conditions of changing environmental factors.

2. Laboratory equipment was used to simulate flight conditions.

The theory was that if a demonstrable effect is proved reproducible and quantified, the data can be corrected by factoring out the impact of these changing environmental parameters using an appropriate mathematical algorithm. Because they were designed for aircraft use, the following instruments were not tested for environmental response: CIC pressure altimeter, Cambridge ambient temperature and dew point temperature sensor, and MRI integrating nephelometer. The remaining instruments on board the helicopter (Table 1) were laboratory-tested using an environmental chamber facility. This chamber had a dynamic range for temperatures of -80° to +100° C and for altitude (pressure) of 600 m to 39 km MSL. A typical test range for temperature was 0° to 40° C and for altitude, 600 m to 3,000 m MSL.

Instrumental drift is defined in this discussion as the difference between the signal change measured in the environmental chamber and the signal change expected due to the change in atmospheric density. For example, the span drift of the REM 612B ozone monitor with altitude is:

(Chamber Drift) - (Density Drift) = Instrumental Drift

(-0.9% of scale/305 m) - (-1.1% of scale 305/m) = +0.2% of scale/305 m

Thus, for a 1,000-m increase in altitude, this instrument shows a drift of only +0.7% of full-scale. Instrument drift results for selected instruments are summarized in Table 2.

TABLE 2. INSTRUMENT DRIFT CORRECTIONS

Instrument	Test	Full-Scale	Change
REM 612B Ozone	Pressure	0.2 ppm	0.7% of full-scale/1,000 m
REM 612B Ozone	Temperature		0.4% of full-scale/° C
Meloy SA160 SO_2	Pressure	1 ppm	2.1% of full-scale/1,000 m
Meloy SA160 SO_2	Temperature		0.36% of full-scale/° C
TECO 14B NO-NO_x	Pressure	1 ppm	6.3% of full-scale/1,000 m
TECO 14B NO-NO_x	Temperature		0.7% of full-scale/° C

The chamber tests were artificial representations of actual conditions of instrument usage. It is indeed important to test the instruments under normal operations to avoid possible artifacts inherent in laboratory tests. However, due to weight and space considerations, it was not practical to carry span gases onto the aircraft during flight; therefore, zero drift of the instruments was the only parameter that was examined for the RAPS helicopter system. Zero drift was examined by having the O_3 and $NO\text{-}NO_x$ instruments sample pure air from zero-grade air bottles, while the other instruments sampled ambient air passed through their internal scrubbers.

Zero drift of the instruments was examined during two in-flight regimes. First, the instruments were allowed to sample clean air during the time when the aircraft was making spiral descents. For this test, the aircraft performed a spiral descent from 1,525 m to 215 m MSL. The time required for such a maneuver is on the order of 10 minutes. Usually, the changes in ambient temperature and pressure are greatest during a spiral, and it is expected that the instruments would be most strongly affected during this period. Figure 6 shows instrument response versus altitude for O_3, NO, NO_x, CO, and SO_2. The outside ambient temperature (OAT) is also plotted for reference. For the instrumentation in this test the drifts observed were negligible, with the exception of that for the CO monitor.

Second, zero drift was examined for the time period of a typical flight, about 3 hours. The drifts of the instruments in this test, with the exception of the CO monitor, were less than 5% of full-scale. To compensate for the drift of these instruments in flight, zero levels were recorded periodically during measurement periods, and a linear interpolation of the zero drift was made to correct those data. (Daily span calibrations of all instruments indicate that the span drift with time was usually less than 5% of full-scale per day.)

The CO analyzer was extremely temperature sensitive, and under certain conditions it was not unusual for the zero drift of this instrument to be 30% to 100% of full-scale during a spiral. The corrections that would have to be made to these CO data are large and, therefore, these data contain a great deal of uncertainty. These data must be assumed to be suspect and if they are to be used in modeling analysis, the user should inspect the in-flight zero data, and compare CO with other pollutants when it peaks.

Interferences

In addition to those interferences specified by the manufacturers of the instruments used in the helicopter operations (Table 3), other interferences are known.

The Meloy SA160-2 is a total sulfur analyzer; it detects hydrogen sulfide (H_2S) and organic sulfides in addition to SO_2. For the Meloy to be specific to SO_2, a catalytic scrubber must be used. This scrubber system was not used on the helicopter system because it increased the response time; hence, H_2S and organic sulfides must be considered as possible positive interferents in the reported SO_2 data.

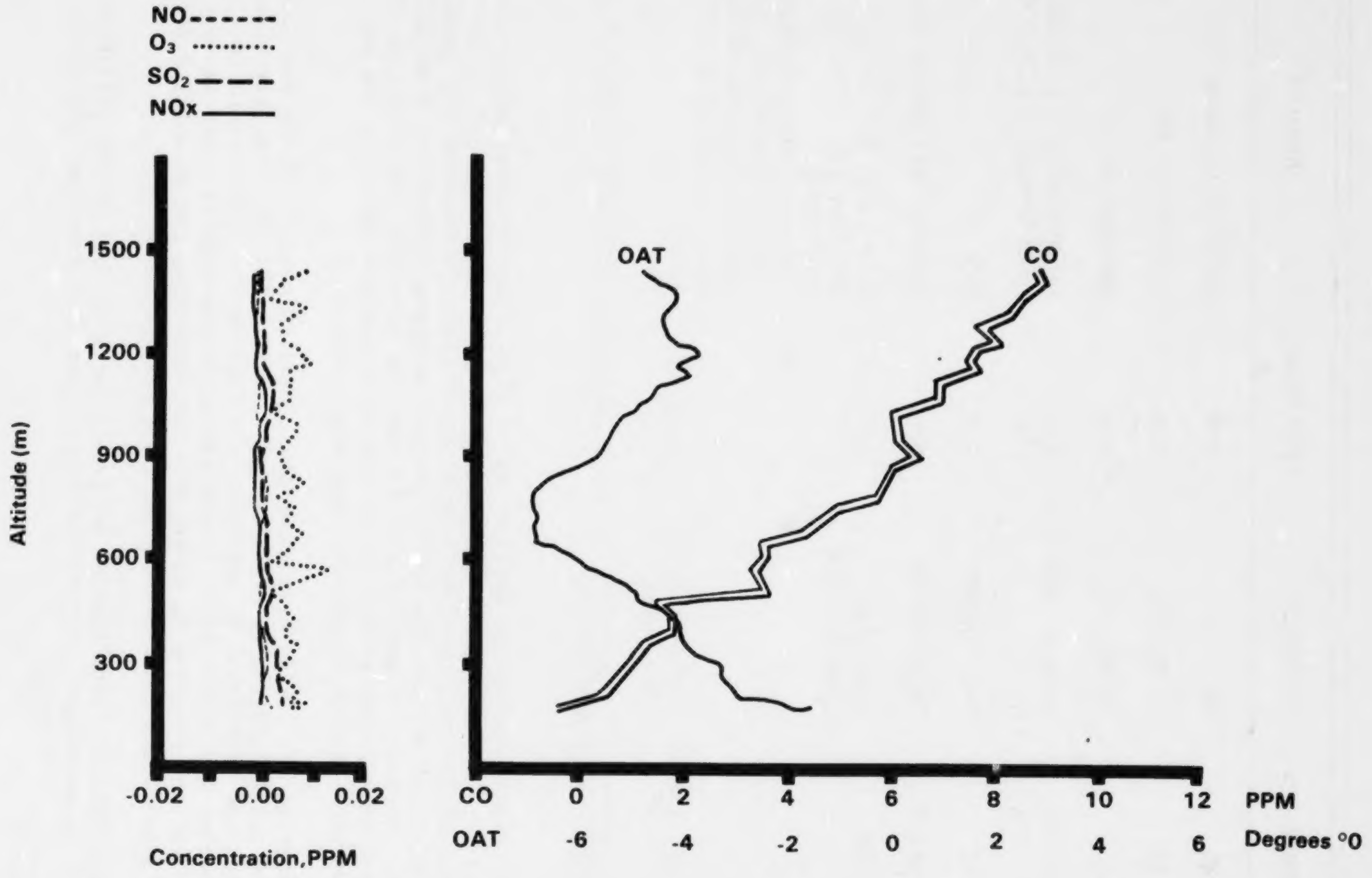


Figure 6. Instrument response to in-flight temperature and pressure changes.

TABLE 3. INSTRUMENT INTERFERENCES (as specified by the manufacturer)

Instrument	Parameter	Interferent	Remarks
REM 612B	O_3	None	Specific to ozone
TECO 14B	$NO/NO_2/NO_x$	None	Specific to NO
ML 8440	$NO/NO_2/NO_x$	None	Specific to NO
Beckman 7000	(Andros 7000)-CO	H_2O CO_2	Interference < 1:10,000 Interference < 1:20,000
MSA 11-2	$THC/CH_4/NMHC$	None	None
Meloy SA160-2	Total Sulfur	None	Measures all sulfur compounds
MRI 1550B	Particles (Visibility)	H_2O	Data valid for aerosols and particulates under following conditions: --without inline heater when relative humidity <65% --with inline heater when relative humidity >65%*
Cambridge 137-C1	Temperature Dew Point	None	None

*Standard Operating Condition

The flame photometric analyzer has a small negative interference since ambient CO_2 levels (approximately 320 ppm) quench the flame and reduce the response of the instrument by approximately 10%. Calibration and operation with identical ambient CO_2 levels produce no appreciable error from this effect. However, it must be assumed that the pure air generator used for calibration had some effect on CO_2 concentration and therefore the SO_2 interference is significant but less than 10%.

Winer et al. (1974) have shown that chemiluminescent NO-NO_2 analyzers respond quantitatively to peroxyacetyl nitrate (PAN) and a variety of organic nitrates and nitrites. In addition, the instruments also respond to nitroethane and nitric acid. These compounds are usually found in very low concentrations relative to NO and NO_2 concentrations and were not expected to be significant interferences in these measurements.

Non-chemical interferences were observed with most of the pollution monitoring equipment. During the July-August 1974 exercise, electronic interference caused by radio transmission from the aircraft was observed. Large spikes in the pollutant monitor readings were detected in test data records corresponding to communications on the FM radios. Faraday cages were built around each pollutant monitor to shield it from radio interference. Little further interference was observed with the instruments other than an occasional small electrical response from the ozone monitor.

Instrument Lag Time Corrections

The following discussion provides the information to make corrections for lag time. The lag times of the air quality instruments flown during the RAPS support missions are functions of the following parameters:

1. instrument detector characteristics and internal flow rate
2. velocity of air stream in the sample manifold which was determined by the air speed of the helicopter
3. the length and diameter of the sample manifold between the air intake probe and the instrument sample inlet

The total lag times of the instruments were determined through a series of in-flight tests. A solenoid valve was placed on the sample inlet probe to inject a span gas into the inlet. The solenoid valve was energized simultaneously with the start of a high-speed strip chart recorder. The length of the chart before the signal began to rise from the background was a measure of the lag time. The lag times, to the nearest second, for all the air quality instruments as used in the RAPS helicopters are listed in Table 4.

TABLE 4. INSTRUMENT LAG TIMES

Instrument	Lag Time
MRI Nephelometer	2 seconds (estimated)
Meloy 160 -SO_2	4 seconds
REM Ozone	5 seconds
ML NO_x	5 seconds
ML NO	6 seconds
Beckman CO	7 seconds
MSA Hydrocarbon	5 seconds (estimated)

The recommended lag corrections for these instruments, a function of the scan rate of the data acquisition system, are listed in Table 5.

The lag and response times of the EG&G temperature probes and altimeters have not been measured at the normal aircraft speed of 60 knots. EG&G lists a response time of 10 seconds in still air.

TABLE 5. LAG CORRECTIONS TO AIR QUALITY INSTRUMENTS

Scan Rate	MRI	Meloy	REM	ML NO	ML NO_x	Beckman	MSA
1 second	2	4	5	6	5	7	5
2 seconds	2	4	4	6	6	6	4
4 seconds	0	4	4	4	4	8	4
5 seconds	0	5	5	5	5	5	5

INSTRUMENT RESPONSE TIME CORRECTIONS

The following discussion provides the information to make corrections for lag time. Each of the monitoring instruments has a finite response time which results in the instruments being unable to measure the input signals exactly. If the instruments are linear first order systems, the input X and the output Y are related as

$$X(t-t_L) = Y(t) + \tau_1 \frac{dY(t)}{dt} \tag{1}$$

where τ_1 = the time constant of the instrument system,

and t_L = the lag time of the instrument system.

All of the instruments used by the RAPS helicopter system may be modeled by equation 1, with one exception. The exception is the Meloy SA-160 SO_2 analyzer which is non-linear and which is discussed separately in this section.

Corrections for Linear Instruments

In general, when the concentration distribution in space is relatively uniform, the derivative $dY(t)/dt$ will be small and the correction ($\tau_1 dY(t)/dt$) need not be made. If the input to the instrument is a ramp function, the output will be an identical ramp, lagging the input by $\tau_1 + t_L$. The only times during the flight when the corrections will be significant will be when the helicopter passes through a plume in flight, or through the top or base of a thermal inversion where both temperature and concentration profiles may have a discontinuity in slope.

The response times of all the instruments were measured both on the bench with simulated flight conditions of flow rate and piping lengths and/or in-flight. The in-flight results are the most reliable for correcting the data because the test conditions are the measurement conditions in flight. The in-flight tests were performed by the injection of span gas through a solenoid valve mounted on the sample inlet tube. A high-speed strip chart recorder was energized simultaneously with the solenoid valve, and several traces of signal rise and fall were obtained. Another technique used was to analyze the signal after the helicopter passed through a plume. Once the plume is passed, the input $X(t)$ is zero and the output $Y(t)$ will be an exponential decay. When the output $Y(t)$ is plotted against time on semilog paper, a straight line with slope $-1/\tau_1$ can be fit to these data. This latter technique has been used successfully with the MRI nephelometer as well as the other pollutant monitors. The time constant of the nephelometer is dependent on the helicopter airspeed since the flow through the detector chamber is provided by ram air into the sample manifold. At 60 knots indicated airspeed, the measured sample flow velocity was only 10 knots and the time constant was on the order of 3 seconds. The measured time constants of the instruments are listed in Table 6.

TABLE 6. TIME CONSTANTS OF LINEAR RAPS INSTRUMENTS

Pollutant	Instrument	Response Time Constant
Aerosol	MRI-Nephelometer	2.5 to 3.5 seconds
NO, NO_x	ML - 5-second setting	6.0 seconds
CO	Beckman/Andros	3.0 to 5.0 seconds
O_3	REM	2.0 to 2.5 seconds

Many numerical procedures are available to obtain derivatives from the tabulated values to make the correction given in equation 1. The procedure recommended is to use a numerical method (Wylie, 1960) as follows:

Given a sequence of five observations of Y at equally spaced intervals of time, $\Delta t = t_2 - t_1 = t_1 - t_0$, as follows

$$Y_0 \mathbin{@} t_0$$

$$Y_1 \mathbin{@} t_1$$

$$Y_2 \mathbin{@} t_2$$

$$Y_3 \mathbin{@} t_3$$

$$Y_4 \mathbin{@} t_4\,,$$

then

$$\frac{(dY)}{(dt)}_{t=2} = \frac{Y_0 - 8Y_1 + 8Y_3 - Y_4}{12\Delta t} \tag{2}$$

and

$$(X)_{t=2} = (Y)_{t=2} + \tau_1\left(\frac{Y_0 - 8Y_1 + 8Y_3 - Y_4}{12\Delta t}\right) . \tag{3}$$

An alternate procedure for analysis of plume study data is to compute the derivative, using the natural logarithm of Y, ℓnY:

$$\frac{dY}{dt} = Y\,\frac{d\ell nY}{dt}, \tag{4}$$

where Y = the concentration in the plume minus the background level. This procedure is preferable because the solution to the equation,

$$X_{max}e^{-\frac{t^2}{2\sigma^2}} = Y + \tau_i\frac{dY}{dt} \tag{5}$$

with initial condition $Y = 0$ at $t = -\infty$, is of the form,

$$Y(t) = Ae^{-t/\tau_1}\left[1 + \mathrm{erf}\left(\frac{t - \sigma^2/\tau_1}{\sigma\sqrt{2}}\right)\right], \tag{6}$$

where erf = the error function,
and A = a constant.

The $\ell n\ Y(t)$ can be expanded as an infinite series in t:

$$\ell n\ Y(t) = \sum_{n=o}^{\infty} a_n t^n \tag{7}$$

where a_n = constants

If one differentiates $\ell nY(t)$, the numerical procedure will give a more accurate value of the derivative since the procedure is most accurate for differentiating polynomial expressions. The correction equation is then:

$$X(t) = Y(t) \left[1 + \tau_1 \frac{d\ell nY(t)}{dt} \right] \tag{8}$$

Corrections for Non-Linear Instruments

The Meloy 160 SO_2 flame photometric analyzer is non-linear by its very nature since the detection technique involves a chemical combination of two sulfur atoms which is a second-order process. In addition, the burner tip and optical windows degrade with time, changing the response character. All tests showed that the normalized responses to positive and negative steps were not identical, as would be the case for the linear instruments. Consequently, no correction could be made to the data by the techniques used for linear instruments. However, for normal conditions where spatial gradients are small, the correction for response time will be negligible.

The recommended technique for correcting the SO_2 data within a plume is to assume that the SO_2 plume has the same dimensions as the NO_x and scattering coefficient (B_{scat}) plumes which can be found with the linear systems approach. The total area (A) under the SO_2-vs-time curve can then be mapped into a plume with the same dimensions (σ) as the NO_x and B_{scat} plume using the Gaussian plume relation:

$$A = X_{max}\sigma \sqrt{2\pi} \tag{9}$$

where X_{max} is the peak SO_2 concentration in a Gaussian plume of area, A, and standard deviation, σ.

INDEPENDENT INTERLABORATORY AUDITS

During all the RAPS field studies, interlaboratory audits were performed on a regular basis by the RAPS St. Louis laboratory staff. These audits were performed after the last flight of the scheduled audit day in two different modes. In the first mode, the audit would be performed as soon as possible after the last flight and before the normal post-calibration procedure described previously in section 4. In the second mode, the audit would be performed as soon as possible after the normal post-calibration procedure and precalibration for the following day's flights.

Two major difficulties were continuously evident in the performance of these audits. The first difficulty arose because the aircraft hangars were not heated or air conditioned, and could not be held at a constant temperature or even within a prescribed temperature range. Although the BDCS was stored in a temperature-controlled calibration trailer the calibrations were performed in the uncontrolled hangar or on the taxi pad in front of the hangar when the aircraft could not be brought inside. In some cases the temperature differences between the calibration trailer and the hangar were as much as ±20° C.

The second problem which occurred throughout the RAPS intensive studies was the effect of ambient CO_2 levels on the Meloy SA-160 flame photometric detectors for SO_2. The St. Louis RAPS audit team used ultrapure air for SO_2 calibration which was deficient in CO_2. This difference resulted in a higher response to audit values than expected from the helicopter calibration values because the CO_2 was not quenching the flame as it would in ambient monitoring or with a calibration source retaining ambient levels of CO_2 (on the order of 320 ppm CO_2).

The audit also showed two problems in the helicopter calibration process which were corrected immediately. The first problem was with the flow system providing dilution ambient air to the NO - NO_x analyzer through the BDCS. During the first three missions, the dilution air was split by a sample "tee" with a portion of the flow going to dilute the secondary NO standard flow and the excess flow exhausting to the atmosphere through a short length of tubing. When the BDCS was being used outside the hangar, the wind blowing across the exhaust tube created a variable back pressure and therefore unstable flow conditions at the "tee". This effect placed the calibration results as much as 25% below the audited values. The problem was corrected by using a longer length of exhaust tubing and shielding the exhaust point from transient air currents. The second problem was discovered during the beginning of the Summer RAPS 1976 mission and was the result of flow pressure gauges failing on the BDCS.

The CO audits documented a major problem with the Andros CO monitor. Large differences were observed whenever the monitor was exposed to rapidly changing temperatures. The bias in the CO audits was primarily due to the extreme temperature sensitivity of the zero response of the instrument. The difference in values of the audit was also partially attributed to varying levels of CO_2 concentration in the different zero-air sources used by the helicopter team and the audit team.

The results of audits over the period of the RAPS studies of 1975 and 1976 are listed in Appendix B. Those for the 1974 studies are unlisted because the audit procedures for that period were unreliable. The values listed are the mean slopes of the regression of helicopter instrument responses to the audit values. In some cases, a single span point was used with no regression calculation. The averages of these audit results are shown in Table 7 along with the number of audits and their standard deviation.

TABLE 7. SUMMARY OF AUDIT RESULTS

Pollutant	Number of Audits	Average Response To Audit Value	Standard Deviation of Response To Audit Value
CO	19	0.910	0.063
SO_2	24	0.934	0.194
NO	25	0.965	0.116
NO_x	26	0.965	0.120
O_3	22	0.964	0.160

5. DATA ACQUISITION AND PROCESSING

DATA ACQUISITION

A schematic flow for the collection and processing of RAPS helicopter data is shown in Figure 7. As shown previously in Figure 3, the analog and digital outputs from the helicopter monitoring system were scanned by an ML Model 7200 R-D2 data acquisition system (DAS) and recorded on 7-track magnetic tape. The data were recorded at 200 bpi in binary coded decimal format. Each scan of the DAS produced a single 132-character record (120 in 1974 missions). The format of the raw data tape and a detailed data element description are shown in Appendix C.

Immediately after a flight, when possible, a voltage dump was obtained using a Versatec line printer. This dump was reviewed by the flight technician to identify any instrument or data system malfunctions, and an attempt was made to correct any malfunctions prior to the next flight. The raw data tapes were labeled, indexed, and archived for ultimate analysis.

DATA EDIT

Final data processing was performed on the U.S. Energy Research and Development Administration's (now the Department of Energy) CDC6400 computer in Las Vegas, Nevada. A system flow for the editing and analysis of the data is shown in Figure 8.

The raw data tape was first processed through the EDIT program which established the format, generated a working file of voltage units, and identified, through an exception-reporting technique, major data anomalies.

The resulting working file was then edited using an interactive text editor. The exceptions list generated by the EDIT program, together with the voltage dump and flight notes, was used to interactively edit the data. The result of this process was an edited voltage file. This file was archived on magnetic tape.

DATA CALIBRATION AND CORRECTION

The edited voltage file was processed through a calibration program, ADCAL, which converted voltages to calibrated engineering units and performed a number of data corrections. Preflight and postflight calibration data were input to the ADCAL program to provide the necessary calibration factors. Samples of the calibration form and coding record are found in Appendix C.

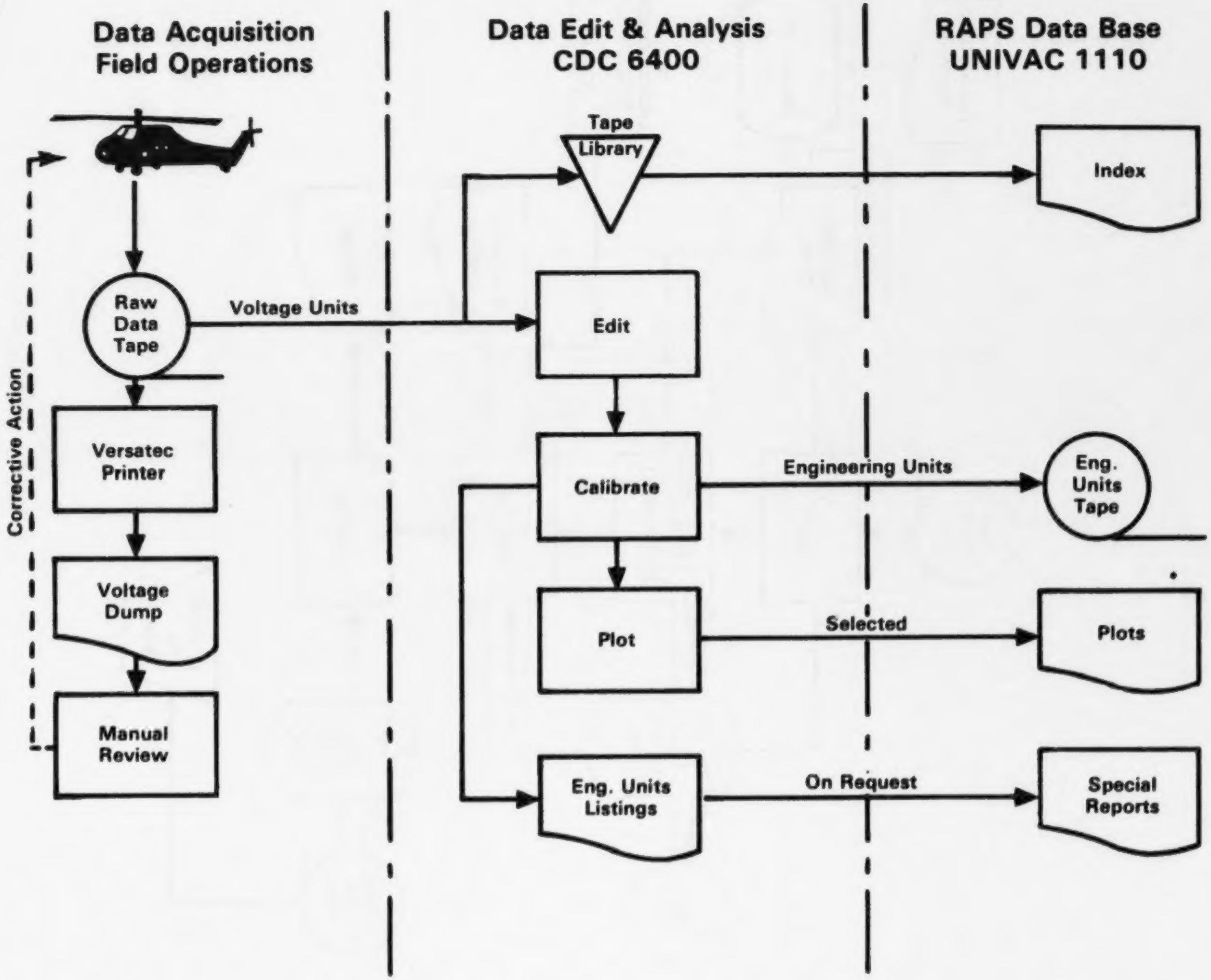

Data Acquisition
Field Operations
Data Edit & Analysis
CDC 6400
RAPS Data Base
UNIVAC 1110
Tape
Library
Index
Raw
Data
Tape
Voltage Units
Edit
Corrective Action
Versatec
Printer
Calibrate
Engineering Units
Eng.
Units
Tape
Voltage
Dump
Plot
Selected
Plots
Manual
Review
Eng. Units
Listings
On Request
Special
Reports

Figure 7. Schematic flow of RAPS helicopter data.

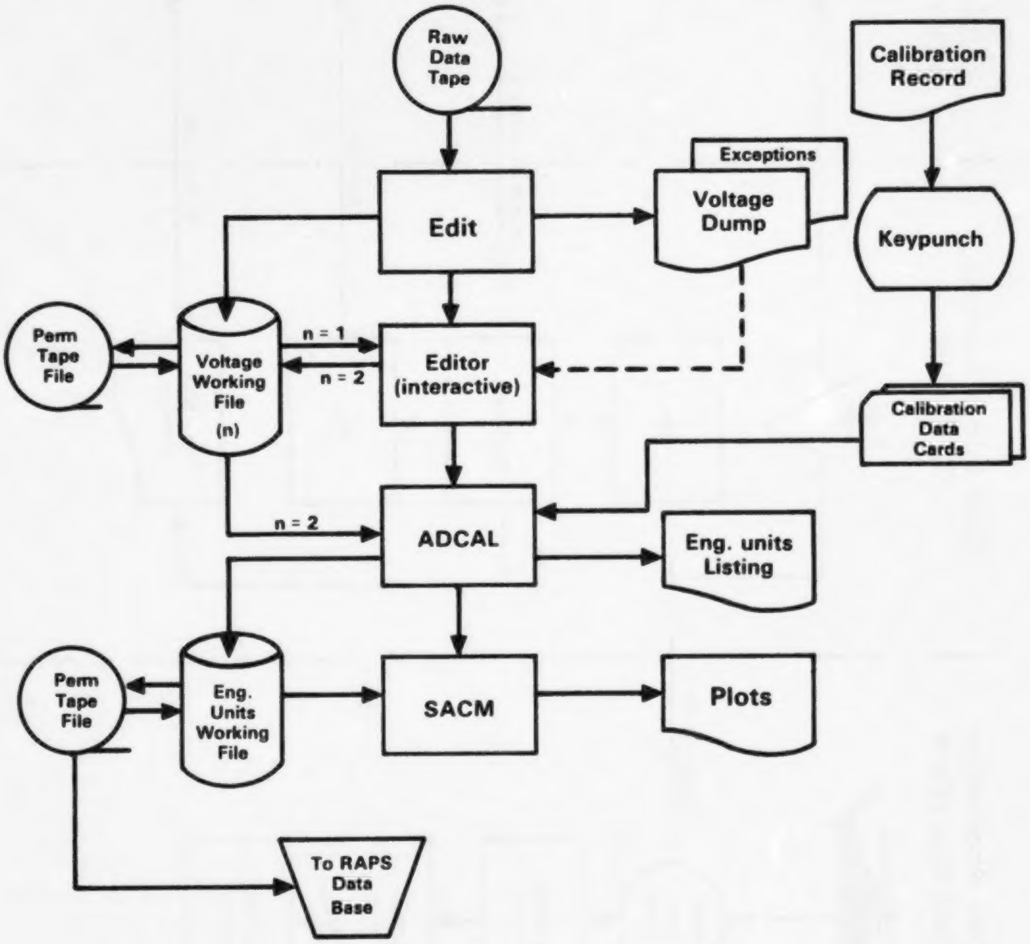

Raw Data Tape
Calibration Record
Exceptions
Voltage Dump
Edit
Keypunch
Perm Tape File
Voltage Working File (n)
n = 1
n = 2
Editor (interactive)
Calibration Data Cards
ADCAL
n = 2
Eng. units Listing
Perm Tape File
Eng. Units Working File
SACM
Plots
To RAPS Data Base

Figure 8. Schematic flow for RAPS helicopter data edit and analysis.

The following calibrations and corrections were made to the data:

1. instrument calibration (zero, span, range)
2. zero drift
3. span drift
4. dew point/frost point correction
5. altimeter calibration
6. airspeed calibration
7. outside air temperature calibration

A detailed description of the algorithms used for each of these calculations is found in Appendix C.

ADCAL produced a listing of calibrated engineering units as shown in Tables 8 and 9. These data, combined by mission, have been provided to the RAPS data base in 9-track ASCII format. A detailed description of the final data file format is found in Appendix C.

Data Analysis Applications

The helicopter data can be displayed using three computer-generated plotting routines:

1. parameter vs. altitude
2. parameter vs. time
3. parameter vs. parameter

Examples of plots are shown in Figures 9 and 10.

TABLE 8. LISTING OF HELICOPTER DATA--ENGINEERING UNITS

INSTRUMENT STATUS: 1131101

TIME	ELAPSED TIME(HH)	DME1 NMI.	DME2 NMI.	VOR DEG.	HDNG DEG.	STATUS	O3 PPM.	NO PPM.	NOX PPM.	SO2 PPM.	CO PPM.	CO T DEG.C	CH4 PPM.	THC PPM.	OAT DEG.C	DPT DEG.C	BSCAT 1/M	ALT FT/MSL	ASPD KNOTS
05:54:50	0.00	-9.9	-9.9	38.1	-9.9	21220440	.000	-.002	.004	-.002	-1.4	27.2	-9.9	-9.9	21.1	12.4	.7	433	54.1
05:54:55	.08	-9.9	-9.9	41.7	-9.9	21220440	.000	-.001	.002	-.002	-1.6	27.1	-9.9	-9.9	20.8	12.2	.8	435	59.5
05:55:00	.17	-9.9	-9.9	243.2	-9.9	21220440	.000	-.001	.003	-.002	-1.7	27.1	-9.9	-9.9	20.2	12.1	.7	436	56.1
05:55:05	.25	-9.9	-9.9	72.9	-9.9	21220440	.000	.001	.004	-.002	-1.6	27.2	-9.9	-9.9	19.9	12.1	.6	437	52.7
05:55:10	.33	-9.9	-9.9	58.6	-9.9	21220440	.000	.002	.004	-.002	-1.9	27.3	-9.9	-9.9	19.0	12.2	.7	436	56.2
05:55:15	.42	-9.9	-9.9	67.5	-9.9	21220440	.001	.002	.004	-.002	-1.8	27.5	-9.9	-9.9	19.6	12.4	.7	441	55.8
05:55:20	.50	-9.9	-9.9	223.6	-9.9	21220440	.000	-.001	.004	-.002	-1.8	27.8	-9.9	-9.9	19.6	12.2	.8	447	52.3
05:55:25	.58	-9.9	-9.9	73.6	-9.9	21220440	.000	-.002	.002	-.002	-2.0	27.8	-9.9	-9.9	19.6	11.9	1.1	447	53.2
05:55:30	.67	-9.9	-9.9	75.6	-9.9	21220440	.000	-.000	.003	-.002	-2.0	28.1	-9.9	-9.9	19.9	12.2	.8	446	51.8
05:55:35	.75	-9.9	-9.9	121.5	-9.9	21223440	.001	.000	.004	-.002	-1.8	28.2	-9.9	-9.9	19.0	12.1	.8	444	56.3
05:58:40	3.83	-9.9	5.0	120.1	-9.9	31223440	.022	.021	.036	.001	3.9	27.3	-9.9	-9.9	18.5	12.4	.6	410	49.6
05:58:45	3.92	-9.9	5.0	135.8	-9.9	01220440	.014	.095	.141	.001	15.6	27.5	-9.9	-9.9	19.6	12.4	.8	419	49.2
05:58:50	4.00	10.9	5.0	124.9	-9.9	01220440	.012	.109	.140	.001	11.3	27.9	-9.9	-9.9	19.3	12.7	.8	450	47.3
05:58:55	4.08	-9.9	5.0	118.7	-9.9	01220440	.009	.093	.123	.001	7.8	28.2	-9.9	-9.9	17.8	12.4	.7	447	45.6
05:59:00	4.17	-9.9	5.1	122.4	-9.9	91220300	.008	.059	.082	.001	3.6	28.5	-9.9	-9.9	17.3	12.7	.7	452	45.2
05:59:05	4.25	-9.9	5.0	124.5	-9.9	91220000	.014	.030	.044	.001	1.9	28.6	-9.9	-9.9	17.1	12.6	1.3	478	45.9
05:59:10	4.33	14.0	5.1	126.3	-9.9	91220000	.019	.012	.023	.001	1.3	28.7	-9.9	-9.9	17.2	12.2	.6	501	47.8
05:59:15	4.42	-9.9	5.1	126.6	-9.9	91220000	.024	.006	.013	.001	1.5	28.8	-9.9	-9.9	17.7	12.3	.6	522	47.8
05:59:20	4.50	0.0	5.2	126.2	-9.9	91220300	.027	.003	.010	.001	1.7	28.8	-9.9	-9.9	17.7	12.3	.6	546	45.2
05:59:25	4.58	-9.9	5.2	126.4	-9.9	11223100	.028	.003	.008	.001	1.8	28.9	-9.9	-9.9	17.9	12.4	.6	570	45.6
05:59:30	4.67	-9.9	5.2	125.7	-9.9	11223100	.031	.002	.008	.001	1.6	28.8	-9.9	-9.9	17.8	12.4	.7	593	45.8
05:59:35	4.75	25.4	5.3	118.4	-9.9	11223100	.033	.000	.006	.001	1.8	28.9	-9.9	-9.9	19.0	12.7	.7	633	45.6
05:59:40	4.83	25.9	5.3	111.9	-9.9	11223100	.034	.000	.005	.001	1.9	28.8	-9.9	-9.9	17.9	11.8	.7	678	47.6
05:59:45	4.92	12.0	5.2	131.3	-9.9	11223100	.035	.000	.005	.001	2.0	28.8	-9.9	-9.9	19.0	11.7	.7	706	46.1
05:59:50	5.00	25.8	5.2	125.6	-9.9	11223100	.035	-.003	.007	.001	1.9	28.8	-9.9	-9.9	17.8	11.9	.6	734	50.4
05:59:55	5.08	25.9	5.1	127.4	-9.9	11223100	.036	.001	.006	.001	2.1	28.9	-9.9	-9.9	17.9	11.3	.7	762	45.5
06:00:00	5.17	25.7	5.0	122.1	-9.9	11223100	.035	.000	.007	.001	2.4	28.9	-9.9	-9.9	17.8	11.7	.7	798	50.2
06:00:05	5.25	25.7	5.0	115.8	-9.9	11223100	.037	.001	.007	.001	2.5	28.9	-9.9	-9.9	17.9	11.9	.7	805	49.8
06:00:10	5.33	25.7	4.8	120.7	-9.9	11223100	.037	-.000	.006	.000	2.4	28.8	-9.9	-9.9	17.9	11.5	.6	822	51.3
06:00:15	5.42	25.7	4.8	125.5	-9.9	11223100	.038	.001	.009	.001	2.5	28.9	-9.9	-9.9	19.0	11.7	.7	851	49.3
06:00:20	5.50	25.8	4.7	127.4	-9.9	11223100	.038	-.001	.008	.000	2.4	28.9	-9.9	-9.9	17.9	11.5	.7	872	51.2
06:00:25	5.58	25.9	4.6	126.4	-9.9	11223100	.037	-.001	.009	.001	2.4	29.0	-9.9	-9.9	19.0	11.4	.7	909	50.6
06:00:30	5.67	26.0	4.6	132.5	-9.9	11223100	.036	.001	.014	.001	2.4	29.0	-9.9	-9.9	17.9	11.3	.6	934	54.1
06:00:35	5.75	.4	4.6	128.8	-9.9	11223100	.036	.002	.013	.001	2.6	29.0	-9.9	-9.9	18.2	11.3	.7	955	51.1
06:00:40	5.83	26.2	4.6	131.4	-9.9	11223100	.036	-.001	.011	.000	2.6	29.0	-9.9	-9.9	17.9	11.0	.7	996	54.3
06:00:45	5.92	26.2	4.6	129.4	-9.9	11223100	.032	-.001	.013	.001	2.4	29.0	-9.9	-9.9	19.0	11.3	.7	1024	56.1
06:00:50	6.00	26.2	4.7	124.6	-9.9	11223100	.029	-.003	.019	.000	2.5	29.1	-9.9	-9.9	19.0	11.3	.7	1036	56.4
06:00:55	6.08	26.2	4.8	124.9	-9.9	11223100	.024	.001	.024	.001	2.4	29.1	-9.9	-9.9	19.2	11.3	.8	1050	53.7
06:01:00	6.17	26.2	4.9	122.3	-9.9	11223100	.021	.004	.022	.001	2.5	29.0	-9.9	-9.9	19.0	10.9	.7	1069	54.8
06:01:05	6.25	26.3	5.0	119.7	-9.9	11223100	.019	.005	.029	.001	2.5	28.9	-9.9	-9.9	19.2	11.5	.8	1099	53.4
06:01:10	6.33	26.3	2.0	121.7	-9.9	11223100	.017	.008	.030	.000	2.5	28.9	-9.9	-9.9	19.0	10.8	.7	1110	55.6
06:01:15	6.42	26.4	5.1	122.4	-9.9	11223100	.015	.008	.033	.001	2.7	28.9	-9.9	-9.9	19.2	10.9	.7	1135	53.8
06:01:20	6.50	26.4	5.2	120.8	-9.9	11223100	.014	.010	.034	.000	2.5	28.9	-9.9	-9.9	19.0	10.7	.7	1156	54.2
06:01:25	6.58	26.4	5.3	118.7	-9.9	11223100	.013	.010	.035	.001	2.5	28.9	-9.9	-9.9	19.2	10.8	.8	1174	55.3
06:01:30	6.67	26.5	5.4	117.8	-9.9	11223100	.012	.011	.038	.001	2.5	28.8	-9.9	-9.9	19.0	10.5	.8	1201	55.8
06:01:35	6.75	26.5	5.5	119.2	-9.9	11223100	.010	.010	.038	.001	2.5	28.9	-9.9	-9.9	19.3	10.5	.9	1230	54.6
06:01:40	6.83	26.5	5.6	116.1	-9.9	11223100	.009	.012	.039	.001	2.3	28.8	-9.9	-9.9	19.3	10.4	1.2	1257	53.9
06:01:45	6.92	26.6	.8	113.3	-9.9	11223100	.009	.015	.046	.001	2.6	28.8	-9.9	-9.9	19.4	10.7	1.5	1284	59.2
06:01:50	7.00	25.5	5.8	114.8	-9.9	11223100	.008	.017	.047	.045	2.8	29.7	-9.9	-9.9	19.5	10.5	2.3	1304	54.3
06:01:55	7.08	26.5	5.9	129.7	-9.9	11223100	.008	.017	.050	.000	2.7	28.9	-9.9	-9.9	19.6	9.5	4.1	1347	59.4
06:02:00	7.17	26.5	6.0	141.5	-9.9	11223100	.013	.010	.046	.130	2.7	28.9	-9.9	-9.9	19.3	9.0	1.9	1388	60.3
06:02:05	7.25	26.5	6.0	136.3	-9.9	11223100	.025	.007	.026	.001	2.5	28.9	-9.9	-9.9	19.2	7.2	.4	1425	62.7
06:02:10	7.33	26.4	6.0	132.4	-9.9	11223100	.035	.003	.013	.001	2.5	28.9	-9.9	-9.9	19.5	7.1	.4	1460	61.8
06:02:15	7.42	26.3	.4	122.4	-9.9	11223100	.041	-.001	.007	.000	2.5	28.9	-9.9	-9.9	19.3	7.2	.4	1487	63.7
06:02:20	7.50	26.2	6.0	127.6	-9.9	11223100	.043	-.000	.007	.001	2.6	29.0	-9.9	-9.9	19.3	7.4	.4	1517	65.8

TABLE 9. DATA REPORT FORMAT

Field	Description
TIME	Central Standard Time (h, min, sec)
ELAPSED TIME	Elapsed time (min) since start of flight
DME1, DME2	Range (nautical miles) from VORTAC station
VOR	Heading (degrees) from VORTAC station to aircraft relative to magnetic north
HDNG	Heading (degrees) of aircraft relative to magnetic north
STATUS	Thumbwheel settings N1 N2 N3 N4 N5 N6 N7 N8

N1 = Flight status

0 = On-ground reference altitude
1 = Valid sampling measurement
2,8 = Instrument zero calibration
7 = No useful data

N2 = DME Station 1 — 1 = Troy
2 = St. Louis
N3 = DME Station 2 — 3 = Maryland Heights
4 = Scott AFB
N4 = VOR Station

N5, N6 = Spiral location (last two digits of RAMS station number)

N7, N8 = Transect tract number or grab-bag sample number

If flight status (N1) equals "0", these four characters are used to record ground elevation (feet) for altimeter calibration

O_3 = Ozone, ppm
NO = Nitric Oxide, ppm
NO_x = Nitric Oxide + Nitrogen Dioxide, ppm
SO_2 = Sulfur Dioxide, ppm
CO = Carbon Monoxide, ppm
CH4 = Methane, ppm

(Continued)

TABLE 9. (Continued)

THC = Total Hydrocarbon as Methane, ppm

B_{SCAT} = Backscatter Coefficient (meters $^{-1}$ x 10^4)

COT = Temperature of CO instrument, ° C

OAT = Outside Air Temperature, ° C

DPT = Dew Point, ° C

ALT = Altitude (feet) referenced to mean sea level

ASPD = Airspeed, knots

INSTRUMENT STATUS - Range setting for instrument

N1 N2 N3 N4 N5 N6 N7

N1 = O_3 instrument range
0 = non-operational
1 = 0 to 20 parts per hundred million (pphm) full-scale
2 = 0 to 200 pphm full-scale

N2 = NO instrument range

0 = non-operational
1 = 0 to 0.2 ppm full-scale
2 = 0 to 0.5 ppm full-scale
3 = 0 to 1.0 ppm full-scale
4 = 0 to 2.0 ppm full-scale
5 = 0 to 5.0 ppm full-scale

N3 = NO_x instrument range (same as NO scale)

N4 = SO_2 instrument range

0 = non-operational
1 = Log
2 = 10^{-4}
3 = 10^{-5}
4 = 10^{-6}
5 = 10^{-7}
6 = 10^{-8}
7 = 10^{-9}

N5 = CO instrument scale

0 = non-operational
1 = 0 to 20 ppm full-scale
2 = 0 to 50 ppm full-scale
3 = 0 to 100 ppm full-scale
4 = 0 to 200 ppm full-scale

(Continued)

TABLE 9. (Continued)

N6 = Hydrocarbon instrument scale

0 = non-operational
1 = 0 to 5 ppm full-scale
2 = 0 to 20 ppm full-scale

N7 = Nephelometer instrument scale

0 = non-operational
1 = A/C
2 = B/D
3 = 0.01 x A/C

Note: A value of -9.9 has been used as a null value indicating invalid data or non-operation of an instrument.

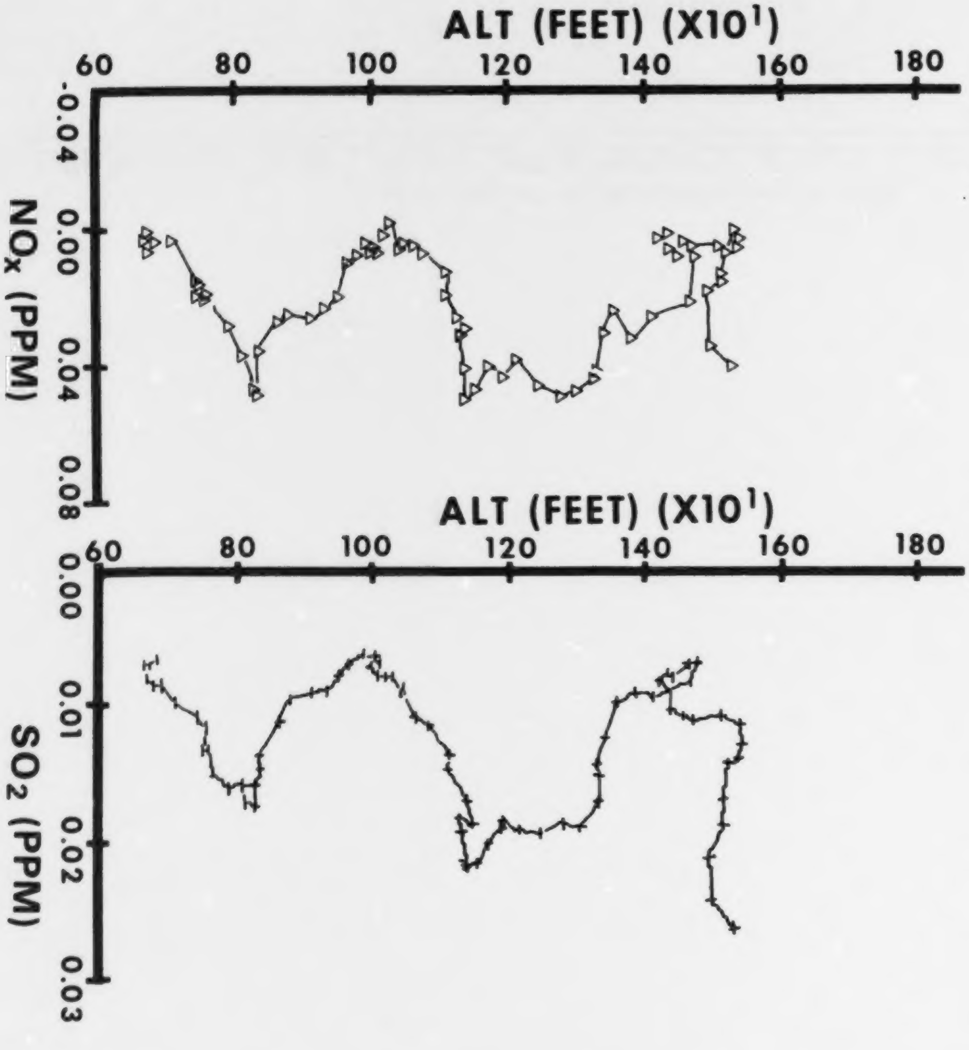


Figure 9. Example of RAPS data plot, parameter vs. altitude.

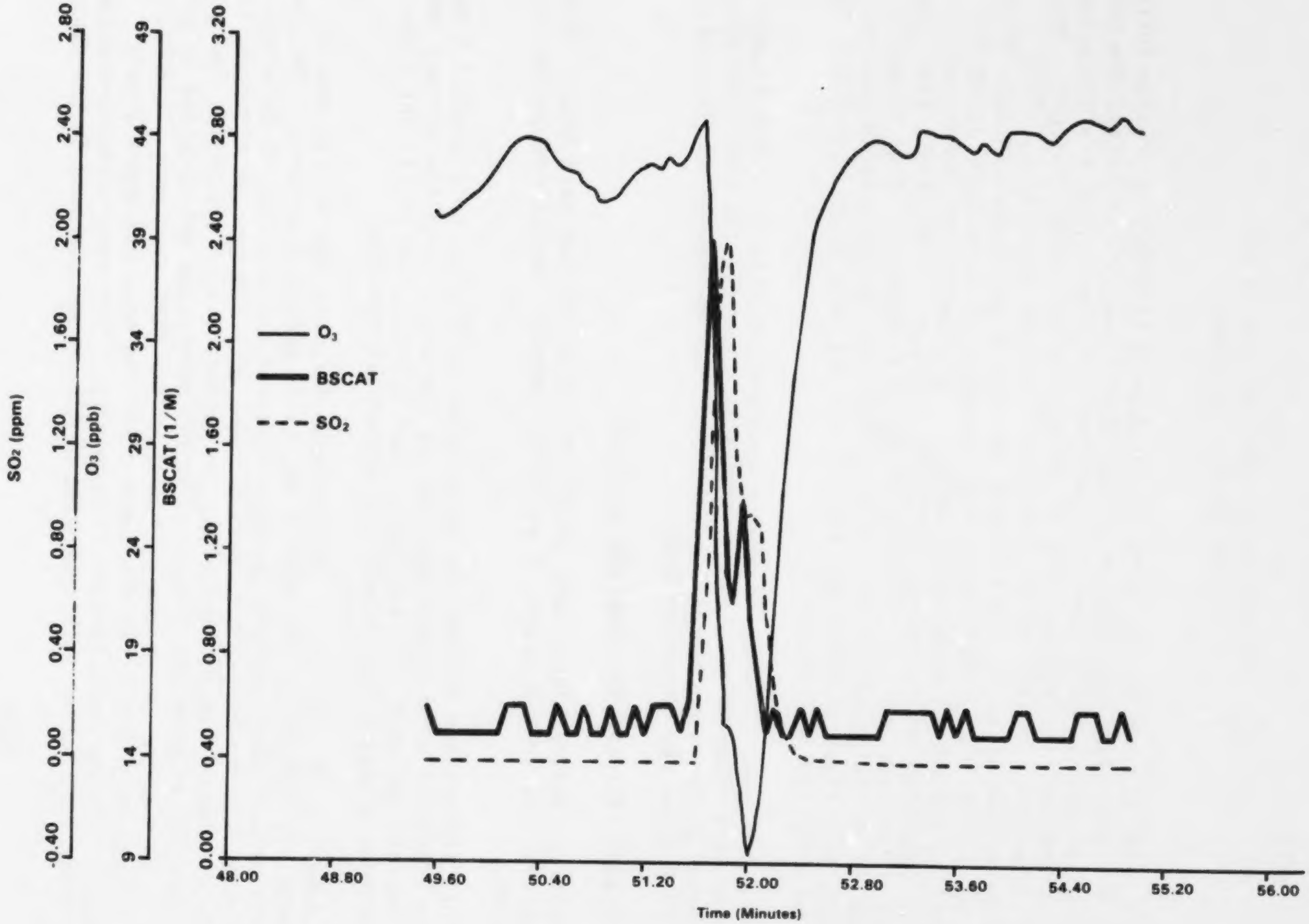


Figure 10. Example of RAPS data plot, parameter vs. time.

6. APPLICATION OF RAPS HELICOPTER DATA TO RAMS SUPPORT MISSIONS

The data obtained during these missions were intended to provide insight to the 3-dimensional distribution of pollutants over St. Louis and how this distribution changes with time. During the 3-year period of field studies, the missions evolved from patterns which visited many RAMS stations a few times to patterns which visited a few RAMS stations many times. This development came about as the missions were optimized to obtain data which would be statistically significant and to aid model developers in making probability statements about their models. The fundamental RAMS support mission consisted of a climb to 1,100 m MSL enroute to the first RAMS station to locate the base and top of the inversion, if present. If no inversion were present or if the inversion base were fairly high, all transects between stations were flown at 600 m MSL and all spirals were flown from 600 m MSL to 60 m AGL over the RAMS stations.

If a low-level (<800-m) inversion were present, the transects between stations were flown 60 m below the inversion base. At the RAMS station, the helicopter would rise through the inversion base and spiral to the surface from 60 m above the inversion base.

RAPS FLIGHT PATTERNS AND SAMPLING CRITERIA

Ideally, 3-dimensional data should be collected over each site. This was not possible because a number of variables imposed limitations on the flight patterns.

Fuel limitations allowed the helicopters to fly for only about 2.5 hours during a typical warm summer day. During the winter when the air was denser, the aircraft got more lift and better fuel economy, and the flight times could be extended almost 1 hour beyond the summer average time.

Lambert Field (St. Louis International Airport) and several smaller airports are located in the greater St. Louis metropolitan area. The air traffic around these airports greatly hindered the mobility of helicopters in this area, and flight patterns were planned accordingly. In addition, FAA and safety considerations did not allow the helicopters to fly across the city at less than 150 m above the ground. Special permission was obtained to spiral down to 60 m above the ground over most of the RAMS stations. This low spiral was allowed only over areas that were clear and open and where a safe emergency landing could be made if necessary. This restriction prevented the helicopter from taking data over some of the ground stations in the downtown area.

Weather conditions also limited helicopter operations. Minimum conditions for VFR (visual flight rules) operation are visibility of 3 miles and a ceiling of at least 300 m AGL. Rain and snow usually prevented flying, and winds greater than 40 knots presented hazardous conditions besides reducing pollutants to low concentrations. Although night flying was possible, the limited visibility presented extra hazards and spirals could not be made to low altitudes.

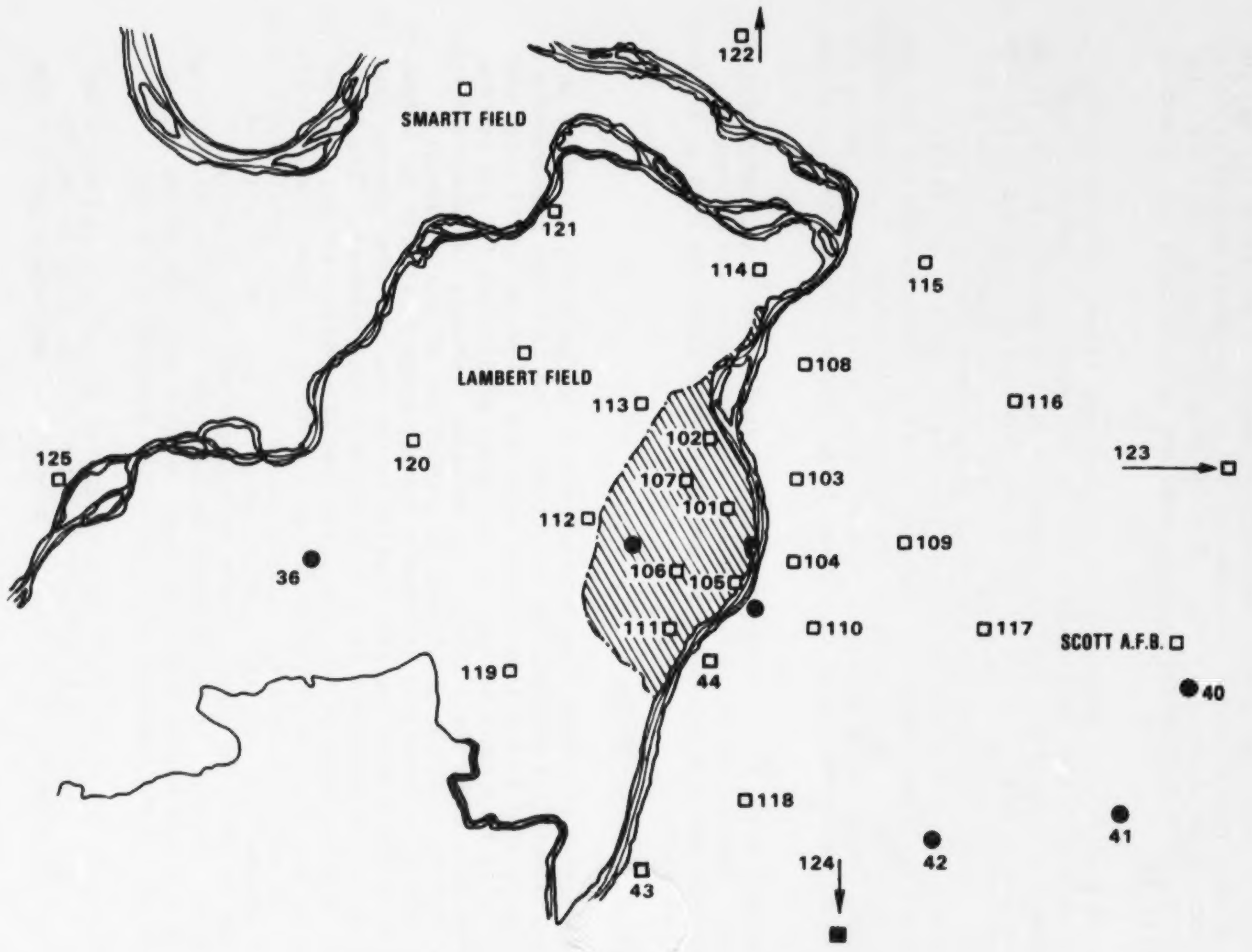
Working within the limitations discussed, the flight patterns evolved considerably with each subsequent visit to St. Louis. The patterns used during each mission are discussed by mission date in Appendix D. The flight patterns are plotted on a map of St. Louis showing the locations of the RAMS stations and helicopter spiral sites, Figure 11. In Appendix D, Tables D-1 and D-2 list the latitude and longitude of each RAMS station and the coordinates of all special helicopter spiral sites used in the flight patterns. Table D-3 shows the locations of VORTAC radio navigation stations and Table D-4 is a user's guide to the individual missions. This table lists the times, patterns and dates for each mission, and a comment section on the table lists instruments that were known to be inoperative at the time of the flight.

The data files will indicate that the CO monitor was functioning most of the time. However, as mentioned earlier, the CO monitor was extremely temperature- and pressure-sensitive and these data should be used with a great deal of caution.

STATISTICAL INTERPRETATIONS

Each spiral was flown at a descent rate of approximately 150 m/min which took approximately 4 minutes, top to bottom. The in-flight measurements should be related to the RAMS station data 60 m below the spiral base, and theoretically they could be used to test model predictions for the average concentrations above the station. The emission inventory is subdivided into hourly average emissions which lead to predictions of hourly average concentrations. Therefore, the hourly average concentration in the volume of air 60 m to 210 m above the RAMS station is the smallest time average that can be computed on a consistent basis with the emission inventory. This hourly average is the average of 60 consecutive 1-minute average values. Because the helicopter was within this volume for only 1 minute, at best, the helicopter data can be construed only as a single random sample from a population of size 60 with unknown mean (μ), and standard deviation (σ). If the standard deviation is zero, the single sample defines the mean of the entire population. However, if the standard deviation of the population is finite, the single sample may be higher or lower than the mean, and on the average would be within one standard deviation of the mean 68% of the time.

When pollutant plumes from elevated sources are present in this volume above the RAMS station, the standard deviation may be quite large. In practice, the plume may alternately be present (1) and absent (0) with the


122
SMARTT FIELD
121
114
115
LAMBERT FIELD
108
113
116
125
120
102
123
107
103
101
112
109
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106
105
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SCOTT A.F.B.
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44
40
118
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124
42
43

Figure 11. Location of RAMS stations and helicopter spiral sites.

computer model predicting the average (1/2), while the helicopter would measure either (1) or (0). Consequently, when these measurements are compared to model predictions, great care must be given to the interpretation of the difference between model prediction and measurement.

SPECIAL MISSIONS FOR PRINCIPAL INVESTIGATORS

In addition to their use in providing information on the vertical dimension of pollutant distribution over St. Louis, the RAPS helicopters also served as a platform for a number of investigators to do special experiments and studies. Experiments covered a wide range of subjects, from simply taking bag samples of air to making complicated plume measurements. Table E-1 of Appendix E gives a brief description of each experiment by date. Bag samples, filter samples and copies of the raw data tapes were normally supplied directly to the principal investigators for their analysis. Table E-1 and Appendix D list those tapes available through the RAPS data base. Principal investigators listed in Appendix E should be contacted directly for further data analysis information.

Some of these data were analyzed by Monitoring Operations Division personnel to study the locations of secondary pollutant (NO_2 and O_3) maxima within the urban plume. A paper was presented at the International Conference on Photochemical Oxidant Pollution and Its Control, in September, 1976 (Hester et al., 1976).

SUMMARY OF HELICOPTER DATA

Appendix F gives a summary of data available through the RAPS data base. Parameters measured along with maxima and minima values are presented for each flight.

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APPENDICES

Appendix A. Calibration Data

Appendix B. Audit Results

Appendix C. Instrument Calibration, Zero, and Span Drift Corrections

Appendix D. Users Guide to RAMS Support Missions

Appendix E. Description of Special Experiments for RAPS Principal Investigators

Appendix F. Summary Report of Helicopter Data

Appendix G. Metric Conversion Table

APPENDIX A

CALIBRATION DATA

Temperature Calibrations

- Table A-1. Temperature Equation Coefficients (EG&G OAT Probes)
- Table A-2. Comparison of Measured to Actual Temperature

Altimeter Calibrations

- Table A-3. Altimeter Calibration Values
- Table A-4. Comparison of Altimeter Calibrations
- Table A-5. Altimeter Equation Coefficients

Altimeter Corrections

Dew Point/Frost Point Correction

- Table A-6. Dew Point/Frost Point Conversions

APPENDIX A

CALIBRATION DATA

TEMPERATURE CALIBRATIONS

The four RAPS helicopter EG&G temperature probes were calibrated against NBS-traceable Rosemount quartz crystal thermometers. Probes 627 and 629 were in use for the first five missions until the failure of the thermoelectric cooling circuitry after the Winter RAPS 1976 mission. Probes 803 and 804 were used for the last two missions and they had identical responses for the temperature range of interest. During the first three missions, no record was kept of which probe (627 or 629) was in which helicopter. For these missions, an average calibration factor was used, which leads to a larger uncertainty than for the later missions. Table A-1 lists the coefficients fit to a cubic equation with voltage (MV) the independent variable, where

$$T°C = C_1 + C_2 (MV) + C_3 (MV)^2 + C_4 (MV)^3.$$

TABLE A-1. TEMPERATURE EQUATION COEFFICIENTS (EG&G OAT Probes)

Probe	C_1	C_2	C_3	C_4
627/629	-16.4743	1.5904	-0.01839	0.000250
627	-16.5424	1.5438	-0.01597	0.000224
629	-16.5051	1.6497	-0.02129	0.000291
803	-16.0111	1.4923	0.01263	0.000174
804	-16.0111	1.4923	0.01263	0.000174

Table A-2 shows the comparison of the calibration equation to the actual temperature.

ALTIMETER CALIBRATIONS

The three CIC altimeters, serial numbers 02244-1, -2, and -3, were calibrated in an environmental chamber at the Las Vegas Laboratory in October, 1976. The results are shown in Table A-3.

TABLE A-2. COMPARISON OF MEASURED TO REFERENCE TEMPERATURE, °C

Reference Temperature	Probe 629	Probe 627	Probes 627/629	Probes 803/804
-10.0	-10.36	-10.13	-10.52	-9.95
- 5.0	- 5.21	-5.15	- 5.47	-5.06
0.0	+ 0.02	-0.09	- 0.30	-0.00
5.0	5.08	4.96	5.28	4.98
10.0	10.04	10.13	10.40	9.94
15.0	14.97	15.25	15.45	15.18
20.0	20.18	19.99	20.03	19.94
25.0	25.38	25.18	25.25	25.02
30.0	29.91	29.78	29.87	29.99
35.0	34.96	34.89	34.92	34.91
40.0	40.15	40.37	40.44	40.06

TABLE A-3. ALTIMETER CALIBRATION VALUES (Average of Three Runs)

Aneroid Barometer (Inches Hg)	Altitude (Feet)*	Altimeter-1 (Volts)	Altimeter-2 (Volts)	Altimeter-3 (Volts)
27.74	2,050	1.030	0.97	0.950
25.84	4,000	1.688	1.62	1.608
23.96	6,000	2.306	2.25	2.256
22.25	8,000	2.958	2.89	2.882
23.12	7,000	2.632	2.58	2.547
24.91	5,000	1.992	1.93	1.933
26.84	3,000	1.348	1.29	1.277
27.74	2,050	1.024	0.97	0.949

*See metric conversion table in Appendix F.

Only one of these altimeters (-3) was calibrated at the factory at the time of purchase in September, 1973. The results shown in Table A-4 indicate a slight change over the 3-year period.

TABLE A-4. COMPARISON OF ALTIMETER CALIBRATIONS - SEPTEMBER 1973 vs. OCTOBER 1976 (Altimeter 02244-3)

Altitude (Feet)	Pressure (Inches Hg)	Voltage (9/73)	Voltage (10/76)
-1,000	31.019	0.0013	---
0	29.921	0.3252	---
1,000	28.856	0.6496	---
2,050	27.740	---	0.949
3,000	26.840	---	1.277
4,000	25.842	1.6185	1.608
5,000	24.910	---	1.933
6,000	23.960	---	2.256
7,000	23.120	---	2.547
8,000	22.250	---	2.882
8,000	22.225	2.9085	---

These data for the three altimeters were fit in the range for altitude (Z), up to 4,000 feet (1,219 m) to an exponential of form

$$P = P_0 e^{-kV}$$

where P_0 and k are coefficients for the altimeter.

The resulting values for P_0 and k are tabulated in Table A-5. The last column contains default coefficients which are used when the altimeter S/N was not recorded. The maximum deviation between predicted and actual pressure is 0.1 inch of mercury (Hg) which corresponds to 30 m. The actual errors will be less since a daily calibration point exists for each flight from the take-off and landing elevations at the airfield.

TABLE A-5. ALTIMETER EQUATION COEFFICIENTS

	S/N -1	S/N -2	S/N -3	S/N -(1,2,3)
P (Inches Hg)	30.990	30.860	31.038	30.868
k (Volts $^{-1}$)	-0.10741	-0.10919	-0.11447	-0.10811

The altimeter calibration assumes a standard atmosphere, defined as 1013.15 millibars and 15° C at MSL, with a standard lapse rate of 0.65° C/100 m. Synoptic scale pressure deviations and temperature variations from the standard lapse rate must be corrected for. The correction assumes that the pressure difference (ΔP) between the standard pressure and measured pressure at the reference altitude, at take-off and landing, remains constant with height. The standard pressure (Ps) at the reference altitude (Zg) is computed by equation A-1. Equations A-2 and A-3 compute the pressure and elevation deviations from the standard equation, A-1.

$$Ps = 1{,}013.25 \left(1.0 - \frac{Zg}{44{,}331\text{ m}}\right)^{5.2568} \qquad \text{(A-1)}$$

$$\Delta P = Ps - Pm \qquad \text{(A-2)}$$

$$Zc = 44{,}331\text{ m} \left[1.0 - \left(\frac{Pm + \Delta P}{1{,}013.25}\right)^{0.19023}\right] \qquad \text{(A-3)}$$

where Ps = standard pressure,
at Zg = reference altitude,
where Pm = measured pressure,
and Zc = the corrected altitude.

ALTIMETER CORRECTIONS

To correct for temperature variation from the standard lapse rate, the helicopter-measured temperature (Tm) at altitude (Z) was used with an assumption of linear temperature variation from the surface temperature (Tg) measured at ground elevation (Zg) to the temperature Tm measured at elevation Z.

$$Z = (Zc - Zg) \frac{1/2\ (Tm + Tg)}{288.15 - 0.65 \left(\frac{Zc + Zg}{2}\right)} + Zg \qquad \text{(A-4)}$$

where Z = the helicopter altitude,
Tm = the absolute temperature, °K, at Z,
and Tg = the absolute temperature, °K, at Zg.

DEW POINT/FROST POINT CORRECTION

For a given vapor pressure, the temperature at which the vapor is in equilibrium with a water surface (dew point) is lower than the temperature at which the vapor is in equilibrium with an ice surface (frost point). This relationship is presented in Table A-6. The standard method for recording these data is in terms of dew point. Therefore, frost point temperatures measured at temperatures below freezing were converted to dew point values. Data from Table A-6 were approximated with three linear equations:

$$DP\ ^\circ F = FP\ ^\circ F - T$$

where $T = 3.75 - 0.1172\ FP$ for $0^\circ \le FP < 32^\circ$ F,

$T = 3.75 - 0.0800\ FP$ for $-30^\circ \le FP < 0^\circ$ F,

$T = 4.75 - 0.0475\ FP$ for $FP < -30^\circ$ F,

DP = dew point, °F,

and FP = frost point, °F.

TABLE A-6. DEW POINT/FROST POINT CONVERSIONS

Below 32°F, dew point hygrometers measure the frost point temperature rather than the dew point. This table enables conversion from dew point to frost point. For a more accurate conversion, consult Smithsonian Meteorological Tables, Table 102, page 371.

F. P.	D. P.	F. P.	D. P.	F. P.	D. P.	F. P.	D. P.
+32	+32.0	+10	+ 7.4	-12	-15.6	-33	-39.3
+31	+30.8	+ 9	+ 6.3	-13	-16.7	-34	-40.3
+30	+29.7	+ 8	+ 5.2	-14	-17.8	-35	-41.4
+29	+28.6	+ 7	+ 4.1	-15	-18.9	-36	-42.4
+28	+27.5	+ 6	+ 2.9	-16	-20.0	-37	-43.5
+27	+26.4	+ 5	+ 1.8	-17	-21.1	-38	-44.5
+26	+25.3	+ 4	+ 0.7	-18	-22.2	-39	-45.6
+25	+24.1	+ 3	- 0.4	-19	-23.3	-40	-46.6
+24	+22.9	+ 2	- 1.5	-20	-24.3	-41	-47.7
+23	+21.8	+ 1	- 2.6	-21	-25.4	-42	-48.7
+22	+20.7	0	- 3.7	-22	-26.4	-43	-49.8
+21	+19.6	- 1	- 4.8	-23	-27.5	-44	-50.8
+20	+18.5	- 2	- 5.8	-24	-28.6	-45	-51.9
+19	+17.4	- 3	- 6.9	-25	-29.6	-46	-52.9
+18	+16.2	- 4	- 8.0	-26	-30.6	-47	-54.0
+17	+15.1	- 5	- 9.1	-27	-31.7	-48	-55.0
+16	+14.0	- 6	-10.2	-28	-32.8	-49	-56.1
+15	+12.9	- 7	-11.3	-29	-33.9	-50	-57.1
+14	+11.8	- 8	-12.4	-30	-35.0	-51	-58.2
+13	+10.7	- 9	-13.5	-31	-36.1	-52	-59.2
+12	+ 9.6	-10	-14.6	-32	-37.2	-53	-60.3
+11	+ 8.5	-11	-15.6	-33	-38.2		

APPENDIX B

AUDIT RESULTS

Table B-1.	Carbon Monoxide (CO)
Table B-2.	Sulfur Dioxide (SO_2)
Table B-3.	Nitrogen Oxide (NO_x)
Table B-4.	Nitric Oxide (NO)
Table B-5.	Ozone (O_3)

TABLE B-1. CARBON MONOXIDE AUDIT RESULTS

Date	Linear Regression	RAPS#
17 Feb 75	y = 0.804x	1
17 Feb 75	y = 1.012x	2
20 Feb 75	y = 0.829x	1
20 Feb 75	y = 0.913x	2
25 Feb 75	y = 1.029x	1
25 Feb 75	y = 0.882x	2
22 Jul 75	y = 0.814x + 0.344	1
26 Jul 75	y = 0.887x	3
17 Feb 76	y = 0.860x - 0.40	3
17 Feb 76	y = 0.945x + 1.050	3
1 Mar 76	y = 0.913x + 0.79	3
11 Mar 76	y = 0.966x - 0.013	3
14 Jul 76	y = 0.929x + 2.787	1
15 Jul 76	y = 0.875x - 1.773	1
27 Jul 76	y = 0.903x + 3.197	2
1 Nov 76	y = 0.866x + 0.407	3
7 Nov 76	y = 0.922x + 1.713	3
8 Nov 76	y = 0.953x + 1.542	3
14 Nov 76	y = 0.983x + 0.7991	3

MEAN OF SLOPES = 0.910

STANDARD DEVIATION = 0.0633

TABLE B-2. SULFUR DIOXIDE AUDIT RESULTS

Date	Linear Regression	RAPS#
17 Feb 75	y = 0.384x + 0.0339*	1
17 Feb 75	y = 0.863x - 0.0003*	2
20 Feb 75	y = 0.943x + 0.021	1
20 Feb 75	y = 0.916x - 0.0004	2
25 Feb 75	y = 0.895x - 0.0021	1
25 Feb 75	y = 0.832x - 0.006	2
26 Jul 75	y = 1.289x + 0.008	3
4 Aug 75	y = 0.922x - 0.023	1
13 Aug 75	y = 1.033x + 0.014	3
16 Feb 76	y = 1.378x - 0.011	3
17 Feb 76	y = 1.141x + 0.000	3
24 Feb 76	y = 1.154x + 0.011	1
1 Mar 76	y = 0.914x - 0.028	3
11 Mar 76	y = 1.159x + 0.022	3
14 Jul 76	y = 0.651x - 0.002	1
15 Jul 76	y = 0.661x - 0.0014	1
27 Jul 76	y = 0.899x - 0.004	2
9 Aug 76	y = 0.746x - 0.004	1
10 Aug 76	y = 0.854x + 0.003	1
31 Oct 76	y = 0.565x + 0.0004*	3
1 Nov 76	y = 0.554x + 0.0012*	3
7 Nov 76	y = 0.844x + 0.0077	3
8 Nov 76	y = 0.751x + 0.008	3
14 Nov 76	y = 0.773x + 0.0087	3

MEAN OF SLOPES = 0.934

STANDARD DEVIATION = 0.194

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*Not included in calculations of mean and standard deviation because of anomalous behavior due to leakage and incorrect thermometer placements.

TABLE B-3. NITROGEN OXIDE AUDIT RESULTS

Date	Linear Regression	RAPS#
17 Feb 75	$y = 0.781x - 0.001$	1
17 Feb 75	$y = 0.717x + 0.006$	2
20 Feb 75	$y = 0.957x + 0.001$	1
20 Feb 75	$y = 0.888x - 0.023$	2
25 Feb 75	$y = 0.983x + 0.0019$	1
25 Feb 75	$y = 0.982x + 0.002$	2
22 Jul 75	$y = 1.168x - 0.009$	1
26 Jul 75	$y = 1.005x - 0.005$	3
4 Aug 75	$y = 0.868x + 0.009$	1
13 Aug 75	$y = 0.928x + 0.002$	3
16 Feb 76	$y = 0.838x + 0.009$	3
17 Feb 76	$y = 0.969x + 0.001$	3
17 Feb 76	$y = 0.951x - 0.002$	1
24 Feb 76	$y = 0.969x - 0.004$	1
3 Mar 76	$y = 1.038x - 0.005$	3
14 Jul 76	$y = 0.951x + 0.003$	1
15 Jul 76	$y = 0.944x + 0.004$	1
27 Jul 76	$y = 0.934x + 0.001$	2
9 Aug 76	$y = 0.913x - 0.004$	1
10 Aug 76	$y = 0.939x - 0.004$	1
31 Aug 76	$y = 1.009x + 0.0046$	3
1 Nov 76	$y = 0.948x + 0.0059$	3
7 Nov 76	$y = 1.054x + 0.0013$	3
8 Nov 76	$y = 1.306x + 0.003$	3
14 Nov 76	$y = 1.086x + 0.0001$	3

MEAN OF SLOPES = 0.965

STANDARD DEVIATION = 0.116

TABLE B-4. NITRIC OXIDE AUDIT RESULTS

Date	Linear Regression	RAPS#
17 Feb 75	$y = 0.776x + 0.001$	1
17 Feb 75	$y = 0.719x + 0.006$	2
20 Feb 75	$y = 0.950x + 0.008$	1
20 Feb 75	$y = 0.883x - 0.016$	2
25 Feb 75	$y = 0.984x - 0.0025$	1
25 Feb 75	$y = 1.000x - 0.001$	2
22 Jul 75	$y = 1.177x - 0.008$	1
26 Jul 75	$y = 1.004x - 0.0005$	3
4 Aug 75	$y = 0.856x + 0.013$	1
13 Aug 75	$y = 0.947x + 0.002$	3
16 Feb 76	$y = 0.859x + 0.000$	3
17 Feb 76	$y = 0.974x - 0.004$	3
17 Feb 76	$y = 0.927x + 0.004$	3
24 Feb 76	$y = 0.961x - 0.002$	1
1 Mar 76	$y = 0.993x - 0.002$	3
11 Mar 76	$y = 1.041x - 0.004$	3
14 Jul 76	$y = 0.980x + 0.002$	1
15 Jul 76	$y = 0.950x + 0.002$	1
27 Jul 76	$y = 0.937x + 0.000$	2
9 Aug 76	$y = 0.861x - 0.014$	1
10 Aug 76	$y = 0.862x - 0.011$	1
31 Oct 76	$y = 0.992x + 0.0013$	3
1 Nov 76	$y = 0.984x - 0.0014$	3
7 Nov 76	$y = 1.048x - 0.0027$	3
8 Nov 76	$y = 1.324x - 0.0021$	3
14 Nov 76	$y = 1.087x + 0.0002$	3

MEAN OF SLOPES = 0.965

STANDARD DEVIATION = 0.120

TABLE B-5. OZONE AUDIT RESULTS

Date	Linear Regression	RAPS#
17 Feb 75	$y = 0.969x + 0.000$	1
17 Feb 75	$y = 1.097x + 0.010$	2
20 Feb 75	$y = 0.793x + 0.000$	1
20 Feb 75	$y = 0.596x + 0.000$	2
25 Feb 75	$y = 1.039x + 0.001$	1
25 Feb 75	$y = 1.007x + 0.005$	2
26 Jul 75	$y = 0.878x + 0.003$	3
4 Aug 75	$y = 0.821x + 0.002$	1
13 Aug 75	$y = 0.807x + 0.013$	3
17 Feb 76	$y = 0.865x - 0.001$	3
24 Feb 76	$y = 0.744x - 0.008$	1
11 Mar 76	$y = 0.922x + 0.002$	3
14 Jul 76	$y = 0.966x + 0.009$	1
15 Jul 76	$y = 1.135x + 0.014$	1
27 Jul 76	$y = 0.796x + 0.003$	2
9 Aug 76	$y = 1.110x - 0.008$	1
10 Aug 76	$y = 1.062x - 0.008$	1
31 Oct 76	$y = 1.153x + 0.004$	3
1 Nov 76	$y = 0.989x + 0.004$	3
7 Nov 76	$y = 1.153x + 0.004$	3
8 Nov 76	$y = 0.991x - 0.003$	3
14 Nov 76	$y = 1.240x + 0.010$	3

MEAN OF SLOPES = 0.964

STANDARD DEVIATION = 0.160

APPENDIX C

INSTRUMENT CALIBRATION, ZERO, AND SPAN DRIFT CORRECTIONS

Calibration

Figure C-1. Helicopter calibration form

Figure C-2. Calibration coding record

Zero Drift

Figure C-3. Zero drift correction scheme

Span Drift

Figure C-4. Span drift correction scheme

Helicopter Data Tape Format

Table C-1. Helicopter Data Tape Format

Table C-2. Helicopter Data Tape Output

Table C-3. Pre- and Post-calibration Factors

Table C-4. ADCAL Calibration Values

Table C-5. Calibrated Engineering Units Listing

Table C-6. Final Data File Format

APPENDIX C

INSTRUMENT CALIBRATION, ZERO, AND SPAN DRIFT CORRECTIONS

CALIBRATION

As discussed in section 5, a calibration zero and single-point span were performed on the ozone, nitric oxide, nitrogen oxide, sulfur dioxide, carbon monoxide, and hydrocarbon instruments before and after each flight. These data were used to establish an instrument calibration factor and to correct for zero and span drift during a flight. In addition, instrument zeroes were obtained during the flight and are indicated by a numerical 2 or 8 coded in the flight status field. Examples of the records for pre- and postcalibration are shown in Figures C-1 and C-2.

ZERO DRIFT

The pre- and postflight, as well as the inflight zero calibrations were used for defining zero drift corrections. A linear interpolation was used to correct voltage values between successive zero calibrations. See Figure C-3.

SPAN DRIFT

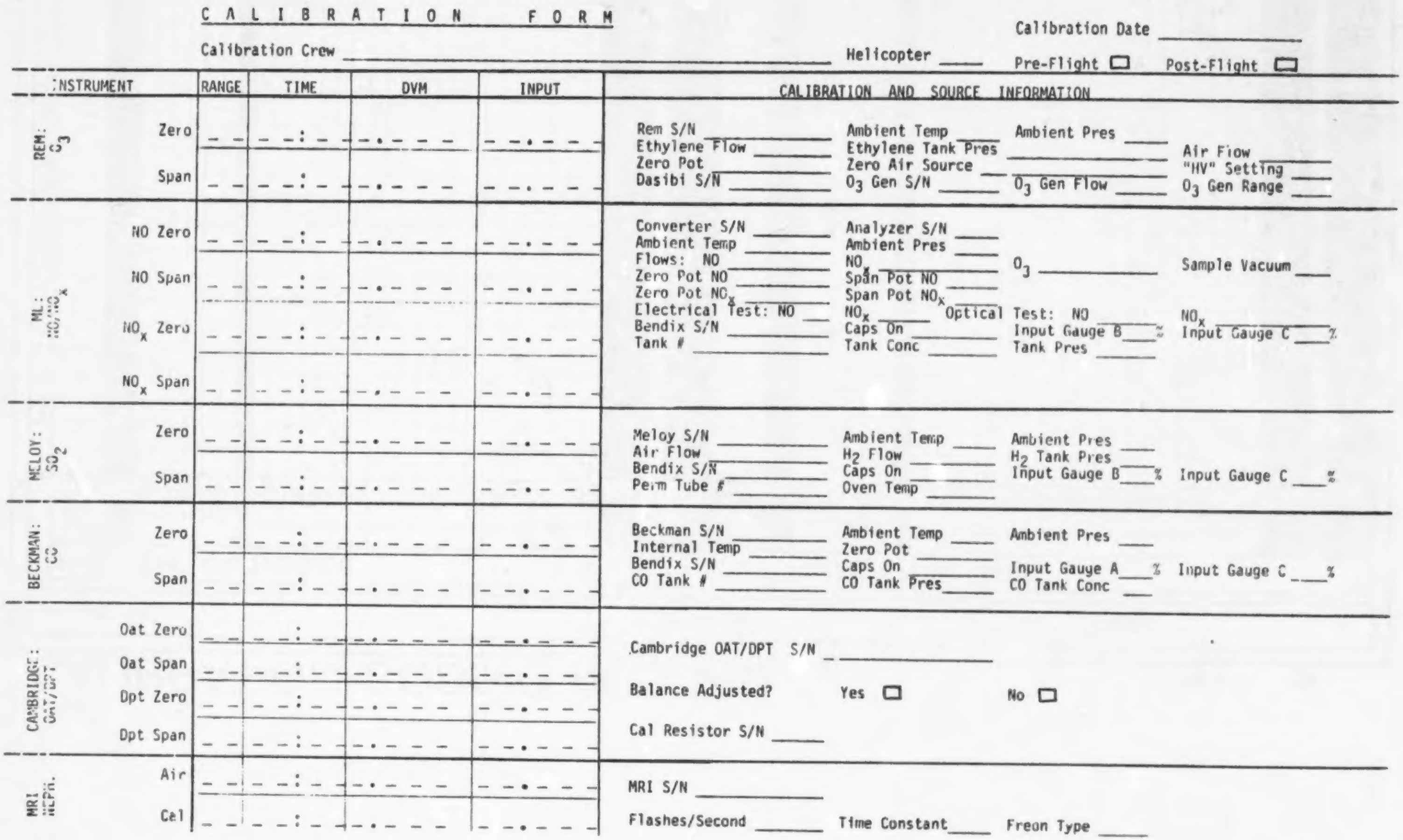
The pre- and postcalibration data were used to correct for span drift during a flight. Two basic assumptions were used:

1. Instrument response is linear as a function of concentration.
2. Instrument response shift is linear as a function of time.

See Figure C-4.

HELICOPTER DATA TAPE FORMAT

The format of the helicopter data tape is described in Table C-1, and the tape output itself is shown in Table C-2. Tables C-3 and C-4 are examples of the pre- and postcalibration data, inflight zero values, and calculated segment slopes which are part of the ADCAL output described previously. Table C-5 describes the calibrated engineering units listing. Table C-6 defines the file format for the data tapes submitted to the RAPS data base.



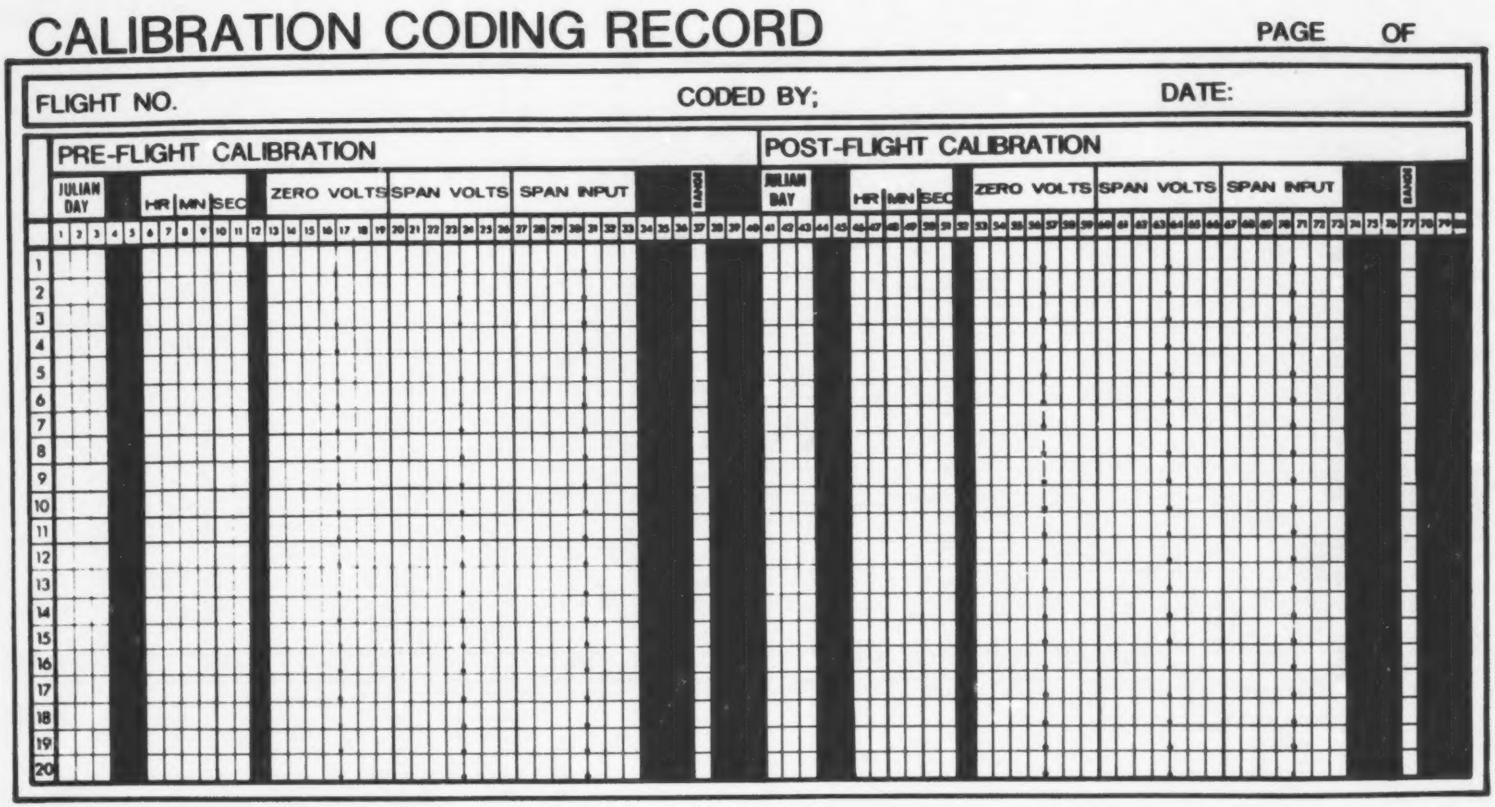
CALIBRATION FORM

Calibration Crew ___ Helicopter ___ Calibration Date ___

Pre-Flight ☐ Post-Flight ☐

INSTRUMENT		RANGE	TIME	DVM	INPUT	CALIBRATION AND SOURCE INFORMATION
REM: O_3	Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	Rem S/N ___ Ambient Temp ___ Ambient Pres ___ Ethylene Flow ___ Ethylene Tank Pres ___ Air Flow ___ Zero Pot ___ Zero Air Source ___ "HV" Setting ___ Dasibi S/N ___ O_3 Gen S/N ___ O_3 Gen Flow ___ O_3 Gen Range ___
	Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
ML: NO/NO_x	NO Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	Converter S/N ___ Analyzer S/N ___ Ambient Temp ___ Ambient Pres ___ Flows: NO ___ NO_x ___ O_3 ___ Sample Vacuum ___ Zero Pot NO ___ Span Pot NO ___ Zero Pot NO_x ___ Span Pot NO_x ___ Electrical Test: NO ___ NO_x ___ Optical Test: NO ___ NO_x ___ Bendix S/N ___ Caps On ___ Input Gauge B ___% Input Gauge C ___% Tank # ___ Tank Conc ___ Tank Pres ___
	NO Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
	NO_x Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
	NO_x Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
MELOY: SO_2	Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	Meloy S/N ___ Ambient Temp ___ Ambient Pres ___ Air Flow ___ H_2 Flow ___ H_2 Tank Pres ___ Bendix S/N ___ Caps On ___ Input Gauge B ___% Input Gauge C ___% Perm Tube # ___ Oven Temp ___
	Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
BECKMAN: CO	Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	Beckman S/N ___ Ambient Temp ___ Ambient Pres ___ Internal Temp ___ Zero Pot ___ Bendix S/N ___ Caps On ___ Input Gauge A ___% Input Gauge C ___% CO Tank # ___ CO Tank Pres ___ CO Tank Conc ___
	Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
CAMBRIDGE: OAT/DPT	Oat Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	Cambridge OAT/DPT S/N ___ Balance Adjusted? Yes ☐ No ☐ Cal Resistor S/N ___
	Oat Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
	Dpt Zero	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
	Dpt Span	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	
MRI NEPH.	Air	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	MRI S/N ___ Flashes/Second ___ Time Constant ___ Freon Type ___
	Cal	_ _	_ _ : _	_ . _ _ _	_ _ . _ _ _	

Figure C-1. Helicopter calibration form.



CALIBRATION CODING RECORD PAGE OF

FLIGHT NO. CODED BY; DATE:

	PRE-FLIGHT CALIBRATION												POST-FLIGHT CALIBRATION											
	JULIAN DAY		HR	MN	SEC		ZERO VOLTS	SPAN VOLTS	SPAN INPUT		RANGE		JULIAN DAY		HR	MN	SEC		ZERO VOLTS	SPAN VOLTS	SPAN INPUT		RANGE	
	1 2 3	4 5	6 7	8 9	10 11	12	13 14 15 16 17 18 19	20 21 22 23 24 25 26	27 28 29 30 31 32 33	34 35 36	37	38 39 40	41 42 43	44 45	46 47	48 49	50 51	52	53 54 55 56 57 58 59	60 61 62 63 64 65 66	67 68 69 70 71 72 73	74 75 76	77	78 79
1																								
2																								
3																								
4																								
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14																								
15																								
16																								
17																								
18																								
19																								
20																								

Figure C-2. Calibration coding record.

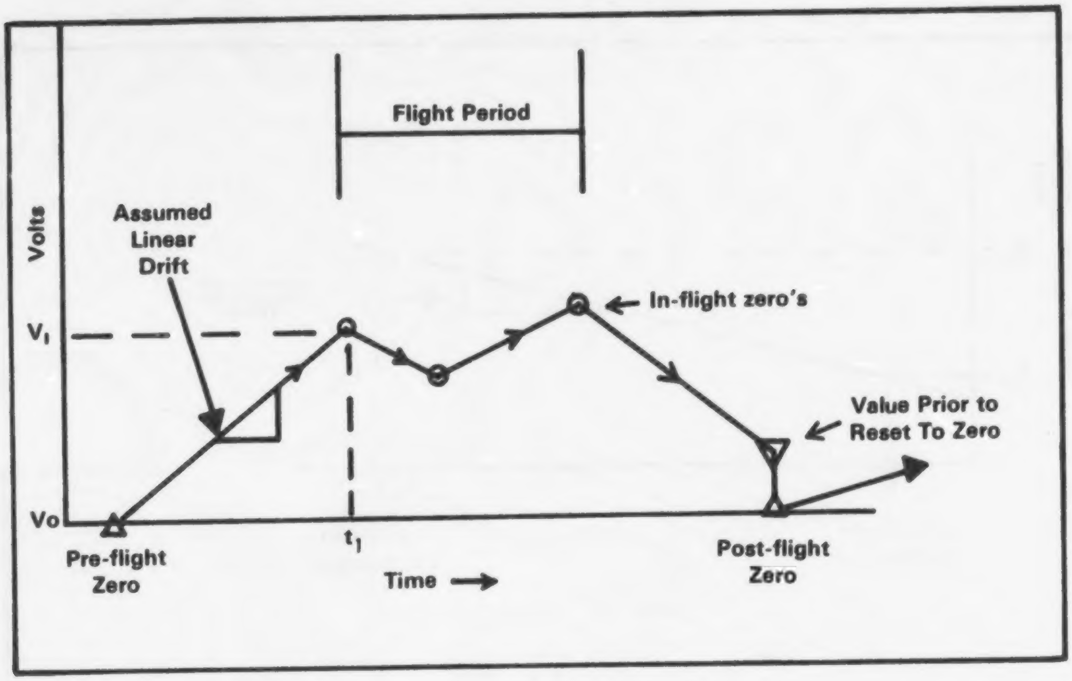

Flight Period
Volts
Assumed Linear Drift
In-flight zero's
V_1
Value Prior to Reset To Zero
Vo
t_1
Pre-flight Zero
Time →
Post-flight Zero

Figure C-3. Zero drift correction scheme

$$f = \frac{V_1 - V_0}{\Delta T}$$

where V_0 = initial zero voltage,
V_1 = shifted zero voltage,
ΔT = elapsed time $(t_1 - t_0)$,
and f = slope

The zero offset at any point in time (t) is then:

$$V_t = V_0 + f\Delta t$$

where V_t = corrected voltage at time (t),
and $\Delta t = t - t_0$, $t_0<t<t_1$.

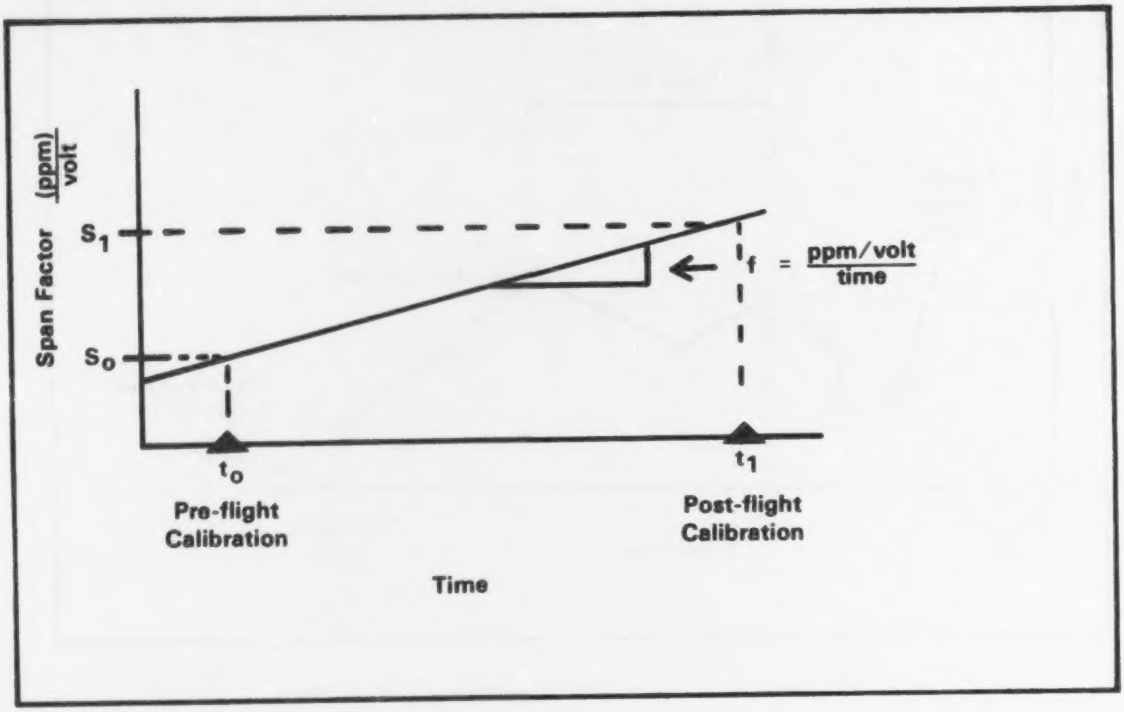

Span Factor (ppm)/volt
S_1
S_0
f = ppm/volt / time
t_0
Pre-flight Calibration
t_1
Post-flight Calibration
Time

Figure C-4. Span drift correction scheme

$$f = \frac{S_1 - S_0}{\Delta t}$$

where S_0 = initial span (ppm/volt)
S_1 = final span (ppm/volt)
Δt = elapsed time ($t_1 - t_0$)
f = slope

In order to convert from voltage (corrected for zero shift) to engineering units at any point in time (t):

$$C_t = V_t \, (S_0 + f\Delta t), \text{ ppm}$$

where C_t = concentration (ppm) at time (t),
V_t = voltage units at time (t),
and $\Delta t = t - t_0$, $t_0 < t < t_1$.

TABLE C-1. HELICOPTER DATA TAPE FORMAT

CHARACTER	FORMAT	DESCRIPTION
1	I1	Helicopter ID 1 = RAPS #1 2 = RAPS #2 3 = RAPS #3
2	I1	Last digit of year
3-5	I3	Julian date
6	I1	O_3 Instrument range 0 = non-operational 1 = 0-20 pphm full-scale (f.s.) 2 = 0-200 pphm f.s.
7	I1	NO instrument range 0 = non-operational 1 = 0-0.2 ppm f.s. 2 = 0-0.5 ppm f.s. 3 = 0-1.0 ppm f.s. 4 = 0-2.0 ppm f.s. 5 = 0-5.0 ppm f.s.
8	I1	NO_x instrument range (same as NO scale)
9	I1	SO_2 instrument range 0 = non-operational 1 = log 2 = 10^{-4} 3 = 10^{-5} 4 = 10^{-6} 5 = 10^{-7} 6 = 10^{-8} 7 = 10^{-9}
10	I1	CO instrument range 0 = non-operational 1 = 0-20 ppm f.s. 2 = 0-50 ppm f.s. 3 = 0-100 ppm f.s. 4 = 0-200 ppm f.s.

(Continued)

TABLE C-1. (Continued)

CHARACTER	FORMAT	DESCRIPTION
11	I1	Hydrocarbon instrument range 0 = non-operational 1 = 0-5 ppm f.s. 2 = 0-20 ppm f.s.
12	I1	Nephelometer instrument range 0 = non-operational 1 = 0 to $10x10^{-4}m^{-1}$ 2 = 0 to $40 \times 10^{-4}m^{-1}$ 3 = 0 to $100 \times 10^{-4}m^{-1}$
13-18	3(I2)	Clock time (h, min, s)
19-20	I2	Bag sample number (00-99)
21-24	F4.1	DME #1
25-28	F4.1	DME #2
29-32	I4	VOR (octal)
33-36	I4	Compass heading (0-359°)
37-38		Not used
39	I1	Flight status 0 = on ground ref. altitude (ft) 1 = sampling mission 2 = instrument zero, in flight 3 = --- 4 = special mission 5 = --- 6 = --- 7 = no useful data 8 = instrument zero, on ground 9 = ---
40	I1	DME #1 station 1 = Troy 2 = St. Louis 3 = Maryland Heights 4 = Scott AFB
41	I1	DME #2 station (same as DME #1 options)

(Continued)

TABLE C-1. (Continued)

CHARACTER	FORMAT	DESCRIPTION
42	I1	VOR station (same as DME #1 options)
43-44	I2	Use code: -when Bit #39 is 1 = last two digits of RAMS site number
43-46	I4	Use code: -when Bit #39 is 0 = reference altitude in feet MSL
45-46	I2	Use code: -when Bit #39 is 1 = bag number (0-99)
47-48		Not used
49-54	F6.4	O_3, volts
55-60	F6.4	NO
61-66	F6.4	NO_x
67-72	F6.4	SO
73-78	F6.4	CO
79-84	F6.4	CO temperature
85-90	F6.4	Short (zero)
91-96	F6.4	Methane
97-102	F6.4	Total hydrocarbons
103-108	F6.4	Temperature
109-114	F6.4	DPT
115-120	F6.4	Visibility, B_{scat}
121-126	F6.4	Altitude (feet)
127-132	F6.4	Airspeed (knots)

```
ID  INSTR. STATUS  TIME  DME 1  DME 2  VOR  HDG  FLT. STAT  USE CODE  O3  NO  NO2  SO2  CO  COT  SHORT  CH4  THC  OAT  D.P.  B-SCAT  ALT.  KNOTS
362161331101055840XX2957005065273597X091229440X0+02407+00394+00753-00022+02038+02727-00000+02927+01447+00270+00219+00614+03643+09309
362161331101055845XX2957005070113597X091220440X0+01607+01809+02749-00027+13185+02749-00000+02931+01441+00271+00219+00772+03571+09436
362161331101055850XX01X9005066153597X091229440X0+01299+02071+02730-00022+02071+02795-00000+02931+01425+00268+00221+00758+03709+09056
362161331101055855XX2957005065073597X091229440X0+03978+01764+02493-00022+05733+02919-00000+02925+01450+00264+00219+00705+03609+09705
362161331101055900XX2957005165613597X091229090X0+00909+01110+01629-00027+01724+02845-00000+02923+01434+00260+00221+00560+03710+09655
362161331101055905XX2957005056113597X091229090X0+01573+00561+00905-00022-00013+02961-00000+02923+01470+00259+00220+01320+03808+09797
362161331101055910XX0140005166353597X091229090X0+02141+00228+09491-00027-00449+02874-00000+02929+01424+00259+00217+00621+03379+09016
362161331101055915XX0000005166403597X091229090X0+02666+00110+00783-00027-00254+02880-00000+02927+01447+00263+00219+00545+03743+09003
362161331101055920XX0000005266343597X091229090X0+02958+00054+00245-00022-00228+02884-00000+02931+01436+00263+00219+00573+04108+09653
362161331101055925XX2957005266363597X091229090X0+03135+00050+00222-00027-00157+02881-00000+02929+01455+00265+00219+00501+04105+09741
362161331101055930XX0291005266293597X091229090X0+03394+00044+00213-00027-00132+02877-00000+02926+01455+00264+00219+00710+04190+09957
362161331101055935XX0254005365033597X091229090X0+03691+00002+00193-00021+00015+02877-00000+02930+01455+00266+00217+00597+04343+09732
362161331101055940XX0259005363713597X091229090X0+03699+00004+00153-00027+00103+02879-00000+02924+01435+00265+00211+00715+04408+09123
362161331101055945XX012XX05267263597X491229090X0+03941+00001+00153-00021+00230+02891-00000+02928+01458+00266+00213+00575+04551+09928
362161331101055950XX0250005266253597X491229090X0+03967-00006+00149-00022+00134+02892-00000+02926+01459+00264+00214+00530+04545+09651
362161331101055955XX0250005166513597X491229090X0+03934+00009+00169-00022+00220+02897-00000+02924+01442+00265+00214+00355+04424+09717
362161331101060000XX0257005065553597X491229090X0+03366+00005+00207-00022+00513+02889-00000+02922+01444+00254+00210+00731+04824+09613
362161331101060005XX0257005054453597X491229090X0+04515+00024+00159-00021+00726+02889-00000+02921+01430+00265+00214+00580+04879+09197
362161331101060010XX0257004965353597X491229090X0+04054-00000+00171-00022+00535+02884-00000+02921+01437+00265+00211+00585+04904+09332
362161331101060015XX0257004856243597X491209090X0+04147+00016+00226-00021+00658+02895-00000+02924+01447+00266+00213+00551+05001+09234
362161331101060020XX0258004765513597X491229090X0+04138-00079+00217-00028+00653+02892-00000+02914+01447+00265+00211+00517+05100+09906
362161331101060025XX0259004566353597X491229090X0+04019-00027+00277-00027+00511+02895-00000+02923+01417+00266+00210+00534+05218+09597
362161331101060030XX0250004567443597X491229090X0+03726+00011+00300-00022+00626+02899-00000+02924+01437+00265+00209+00516+05303+10361
362161331101060035XX0034004566713597X491229090X0+03630+00029+00319-00027+00343+02901-00000+02929+01415+00257+00209+00715+05311+09793
362161331101060040XX0262004567273597X491229090X0+03764-00015+00279-00022+00720+02909-00000+02919+01450+00265+00207+00734+05609+10415
362161331101060045XX0262004567003597X491229090X0+03566-00000+00795-00021+00252+02899-00000+02925+01453+00266+00207+00595+05600+10752
362161331101060050XX0262004765123597X491229090X0+03087-00050+00421-00028+00759+02906-00000+02919+01444+00266+00207+00572+05554+10813
362161331101060055XX0250004266153597X491229090X0+02645+00024+00515-00027+00840+02912-00000+02929+01455+00257+00207+00752+05808+10495
362161331101060100XX0262004565573597X491229090X0+02379+00077+00406-00023+00774+02906-00000+02924+01450+00266+00205+00505+05747+10513
362161331101060105XX0263005065223597X491229090X0+02153+00083+00515-00027+00725+02902-00000+02927+01450+00257+00207+00770+05801+10337
362161331101060110XX0263002065713597X491229090X0+01874+00147+00531-00022+00724+02906-00000+02924+01447+00266+00205+00560+05902+10436
362161331101060115XX0264005165513597X491229090X0+01672+00144+00593-00021+00773+02906-00000+02907+01440+00267+00205+00723+05965+10515
362161331101060120XX0264005265573596X491229090X0+01548+00189+00713-00021+00711+02907-00000+02979+01471+00265+00204+00715+06014+10395
362161331101060125XX0264005765263596X491229090X0+01422+00192+00720-00021+00756+02909-00000+02965+01434+00267+00205+00715+06096+10597
362161331101060130XX0265005464743595X491229090X0+01300+00209+00777-00022+00795+02870-00000+02981+01416+00265+00204+00741+06101+10547
362161331101060135XX0265005565143595X491229090X0+01182+00187+00798-00027+00735+02877-00000+02975+01428+00269+00201+00992+06275+10473
362161331101060140XX0265005564513595X491229090X0+01076+00220+00909-00022+00611+02876-00000+02979+01417+00268+00201+01191+06466+10522
362161331101060145XX0260007964113595X491229090X0+00974+00287+00929-00021+00269+02876-00000+02977+01420+00269+00204+01054+06451+11146
362161331101060150XX0265005964223595XX1122310XX0+00918+00313+00952+00047+01950+02872-00000+02979+01427+00270+00203+00501+06507+10596
362161331101060155XX0266005967043595XX1122310XX0+00939+00315+01019+00045+00940+02879-00000+02977+01447+00271+00214+00411+06598+11194
362161331101060200XX0265006071123595XX1122310XX0+01475+00189+00978+01074+00715+02897-00000+02975+01477+00277+00199+01905+06706+11554
362161331101060205XX0265004970173595XX1122310XX0+03758+00136+00553-00027+00739+02891-00000+02989+01427+00276+00175+00447+06931+12015
362161331101060210XX0264005067423595XX1122310XX0+03860+00063+00310-00022+00737+02892-00000+02985+01414+00279+00174+00415+07021+11946
362161331101060215XX0263000465513595XX1122310XX0+04463-00020+00192-00022+00777+02893-00000+02987+01428+00277+00175+00765+07111+12222
362161331101060220XX0262000565475595XX1122310XX0+04732-00009+00193-00027+00927+02895-00000+02978+01427+00277+00177+00795+07152+12436
362161331101060225XX0262005070073595XX1122310XX0+04993+00000+00179-00022+00950+02895-00000+02959+01424+00279+00174+00909+07304+11947
362161331101060230XX0261006067413595XX1122310XX0+04900+00037+00103-00027+00925+02895-00000+02931+01411+00277+00175+00580+07306+12481
362161331101060235XX0260005066273596XX1122310XX0+04739+00049+00155-00027+01810+02895-00000+02953+01412+00279+00171+00510+07459+12035
362161331101060240XX0260005966073596XX1122310XX0+05087+00088+00166-00021+01949+02895-00000+02931+01413+00277+00173+01000+07574+12827
362161331101060245XX0260005966103596XX1122310XX0+05538+00025+00151-00027+02659+02892-00000+02931+01445+00278+00177+00452+07666+12537
362161331101060250XX0259001665743595XX1122310XX0+06003+00022+00180-00022+01010+02886-00000+02932+01410+00277+00178+00437+07758+12056
362161331101060255XX0259005866353596XX1122310XX0+05331-00007+00174-00021+01315+02885-00000+02874+01422+00277+00179+00430+07826+13130
```

TABLE C-2. HELICOPTER DATA TAPE OUTPUT

TABLE C-3. PRE- AND POST-CALIBRATION FACTORS

CALIBRATION FACTORS:

INSTRUMENT RANGE SETTING

	0	1	2	3	4	5	6	7	8	9
O3	0.00	.10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NO	0.00	.10	.25	.50	1.00	2.50	0.00	0.00	0.00	0.00
NOX	0.00	.10	.25	.50	1.00	2.50	0.00	0.00	0.00	0.00
SO2	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO	0.00	10.00	25.00	50.00	100.00	0.00	0.00	0.00	0.00	0.00
CH4	0.00	5.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
THC	0.00	5.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NEPH	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PRE-CALIBRATION:

	DAY	TIME	ZERO VOLTS	SPAN VOLTS	INPUT	R
O3	215.	19.45. 0.	0.000	1.580	.158	1
NO	215.	21.16. 0.	.001	.981	.491	3
NOX	215.	21.10. 0.	.001	.981	.491	3
SO2	215.	23.15. 0.	-.002	.330	.413	1
CO	215.	23. 5. 0.	0.000	1.470	14.690	1
CH4	215.	23. 0. 0.	-0.000	-0.000	-0.000	0
THC	215.	23. 0. 0.	-0.000	-0.000	-0.000	0
NEPH	215.	23.10. 0.	.023	.790	7.870	1

POST-CALIBRATION

	DAY	TIME	ZERO VOLTS	SPAN VOLTS	INPUT	R
O3	216.	20. 6. 0.	-.017	1.829	.149	1
NO	216.	19.44. 0.	.001	1.360	.762	3
NOX	216.	19.44. 0.	.010	1.350	.762	3
SO2	216.	23. 5. 0.	.002	.420	.413	1
CO	216.	20. 6. 0.	-.170	1.275	14.680	1
CH4	216.	20. 0. 0.	-0.000	-0.000	-0.000	0
THC	216.	20. 0. 0.	-0.000	-0.000	-0.000	0
NEPH	216.	22.57. 0.	.022	.790	7.780	1

TABLE C-4. ADCAL CALIBRATION VALUES

```
NEPHELOMETER ZERO DATA:  TIMES=23.10. 0. 22.57. 0.  VOLTAGES=  .0230   .0220  SLOPE=  -.000000


ZERO LEVEL DATA:

  TIME         O3         NO         NOX        SO2         CO        CH4        THC    SEGMENT

23:15:00    0.0000      .0010      .0010     -.0020     0.0000    -0.0000    -0.0000              PRE-CAL.
                                                                                          1
05:55:35     .0042     -.0003      .0062     -.0025     -.1820      .2935      .1438              IN-FLT-ZRO
                                                                                          2
07:25:05     .0120     -.0005      .0082     -.0026      .0989      .2881      .1414              IN-FLT-ZRO
                                                                                          3
08:25:50     .0302     -.0010      .0055     -.0025     -.0406      .2865      .1420              IN-FLT-ZRO
                                                                                          4
23:05:00    -.0170      .0010      .0100      .0020     -.1700    -0.0000    -0.0000              POST-CAL.
                                                                                          5


SEGMENT SLOPES:

  SEGMENT       O3         NO         NOX        SO2        CO         CH4        THC

     1       .000000  -.000000    .000000   -.000000  -.000008    .000012    .000006

     2       .000031  -.000000    .000000   -.000000   .000052   -.000001   -.000000

     3       .000005  -.000000   -.000001    .000000  -.000038   -.000000    .000000

     4      -.000001   .000000    .000000    .000000  -.000002   -.000005   -.000003


GAIN INFORMATION:        O3         NO         NOX        SO2         CO         CH4        THC        NEPH

SPAN FACTOR(UNITS/VOLT):
     PRE-FLIGHT        .1000      .5005      .5005     1.2515     9.9864     0.0000     0.0000     9.9620
     POST-FLIGHT       .0810      .5603      .5644      .9833    11.5137     0.0000     0.0000     9.3744

NORMALIZED SPAN:
     PRE-FLIGHT       1.0000     1.0010     1.0010     1.2515      .9996     0.0000     0.0000      .9962
     POST-FLIGHT       .8096     1.1206     1.1289      .9833     1.1514     0.0000     0.0000      .9974

SEGMENT SLOPES:   -.0000022   .0000015   .0000016  -.0000031   .0000020 0.0000000 0.0000000   .0000000


ALTITUDE REFERENCE INFORMATION:   REFERENCE FEET= 440              CORRECTION =  -.3379
                                  ALTITUDE VOLTAGE=   .3693        TEMPERATURE DEGREES CELSIUS= 18.?
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TABLE C-5. CALIBRATED ENGINEERING UNITS LISTING

INSTRUMENT STATUS: 1331101

TIME	ELAPSED TIME(MN)	DME1 NMI.	DME2 NMI.	VOR DEG.	HDNG DEG.	STATUS	O3 PPM.	NO PPM.	NOX PPM.	SO2 PPM.	CO PPM.	CO T DEG.C	CH4 PPM.	THC PPM.	OAT DEG.C	DPT DEG.C	BSCAT 1/M	ALT FT/MSL	ASPD KNOTS
05:54:50	0.00	-9.9	-9.9	38.1	-9.9	21220440	.000	-.002	.004	-.002	-1.4	27.2	-9.9	-9.9	21.1	12.6	.7	433	59.1
05:54:55	.08	-9.9	-9.9	41.7	-9.9	21220440	.000	-.001	.002	-.002	-1.6	27.1	-9.9	-9.9	20.8	12.2	.8	435	59.5
05:55:00	.17	-9.9	-9.9	243.2	-9.9	21220440	.000	-.001	.003	-.002	-1.7	27.1	-9.9	-9.9	20.2	12.1	.7	436	56.1
05:55:05	.25	-9.9	-9.9	72.9	-9.9	21220440	.000	.001	.004	-.002	-1.6	27.2	-9.9	-9.9	19.9	12.1	.6	437	52.7
05:55:10	.33	-9.9	-9.9	58.6	-9.9	21220440	.000	.002	.004	-.002	-1.9	27.3	-9.9	-9.9	19.0	12.2	.7	436	56.2
05:55:15	.42	-9.9	-9.9	67.5	-9.9	21220440	.001	.002	.004	-.002	-1.8	27.5	-9.9	-9.9	19.6	12.4	.7	441	55.0
05:55:20	.50	-9.9	-9.9	223.6	-9.9	21220440	.000	-.001	.004	-.002	-1.9	27.8	-9.9	-9.9	19.0	12.2	.8	447	52.3
05:55:25	.58	-9.9	-9.9	73.6	-9.9	21220440	.000	-.002	.002	-.002	-2.0	27.8	-9.9	-9.9	19.6	11.9	1.1	447	53.2
05:55:30	.67	-9.9	-9.9	75.6	-9.9	21220440	.000	-.000	.003	-.002	-2.0	28.1	-9.9	-9.9	19.9	12.2	.8	446	51.0
05:55:35	.75	-9.9	-9.9	121.5	-9.9	21220440	.001	.000	.004	-.002	-1.8	28.2	-9.9	-9.9	19.0	12.1	.9	444	54.3
05:58:40	3.83	-9.9	5.0	120.1	-9.9	31220440	.022	.021	.036	.001	3.9	27.3	-9.9	-9.9	18.5	12.4	.6	430	49.6
05:58:45	3.92	-9.9	5.0	135.8	-9.9	31220440	.014	.095	.141	.001	15.6	27.5	-9.9	-9.9	19.6	12.4	.8	439	49.2
05:58:50	4.00	10.9	5.0	124.9	-9.9	01220440	.012	.109	.140	.001	11.3	27.9	-9.9	-9.9	19.3	12.7	.8	450	47.3
05:58:55	4.08	-9.9	5.0	118.7	-9.9	31220440	.009	.093	.123	.001	7.8	28.2	-9.9	-9.9	17.8	12.4	.7	447	45.4
05:59:00	4.17	-9.9	5.1	122.4	-9.9	91220000	.008	.059	.082	.001	3.6	28.5	-9.9	-9.9	17.3	12.7	.7	452	45.2
05:59:05	4.25	-9.9	5.0	124.5	-9.9	91220000	.014	.030	.044	.001	1.9	28.6	-9.9	-9.9	17.1	12.6	1.3	478	45.9
05:59:10	4.33	14.0	5.1	126.3	-9.9	91220000	.019	.012	.023	.001	1.3	28.7	-9.9	-9.9	17.2	12.2	.6	501	47.0
05:59:15	4.42	-9.9	5.1	126.6	-9.9	91220000	.024	.006	.013	.001	1.5	28.8	-9.9	-9.9	17.7	12.3	.6	522	47.0
05:59:20	4.50	0.0	5.2	126.2	-9.9	91220000	.027	.003	.010	.001	1.7	28.8	-9.9	-9.9	17.7	12.3	.5	546	45.2
05:59:25	4.58	-9.9	5.2	126.4	-9.9	11223100	.028	.003	.008	.001	1.6	28.8	-9.9	-9.9	17.9	12.4	.6	570	45.6
05:59:30	4.67	-9.9	5.2	125.7	-9.9	11223100	.031	.002	.008	.001	1.6	29.0	-9.9	-9.9	17.8	12.4	.7	593	46.8
05:59:35	4.75	25.4	5.3	118.4	-9.9	11223100	.033	.000	.006	.001	1.8	28.9	-9.9	-9.9	18.0	12.2	.7	633	45.6
05:59:40	4.83	25.9	5.3	111.9	-9.9	11223100	.034	.000	.005	.001	1.9	28.8	-9.9	-9.9	17.9	11.5	.7	678	47.6
05:59:45	4.92	12.0	5.2	131.3	-9.9	11223100	.035	.000	.005	.001	2.0	28.8	-9.9	-9.9	18.0	11.7	.7	706	46.1
05:59:50	5.00	25.8	5.2	125.6	-9.9	11223100	.035	-.000	.007	.001	1.9	28.8	-9.9	-9.9	17.8	11.9	.6	734	50.4
05:59:55	5.08	25.9	5.1	127.4	-9.9	11223100	.036	.001	.006	.001	2.1	28.9	-9.9	-9.9	17.9	11.9	.7	762	45.5
06:00:00	5.17	25.7	5.0	122.1	-9.9	11223100	.036	.000	.007	.001	2.4	28.9	-9.9	-9.9	17.8	11.7	.7	788	50.2
06:00:05	5.25	25.7	5.0	115.8	-9.9	11223100	.037	.001	.007	.001	2.5	28.9	-9.9	-9.9	17.9	11.9	.7	805	48.0
06:00:10	5.33	25.7	4.8	120.7	-9.9	11223100	.037	-.000	.006	.000	2.4	28.8	-9.9	-9.9	17.9	11.8	.6	822	51.3
06:00:15	5.42	25.7	4.8	125.5	-9.9	11223100	.038	.001	.009	.001	2.5	28.9	-9.9	-9.9	18.0	11.7	.7	851	49.3
06:00:20	5.50	25.8	4.7	127.4	-9.9	11223100	.038	-.001	.008	.000	2.4	28.9	-9.9	-9.9	17.9	11.5	.7	872	51.2
06:00:25	5.58	25.9	4.6	126.4	-9.9	11223100	.037	-.001	.009	.001	2.4	29.0	-9.9	-9.9	18.0	11.4	.7	909	50.6
06:00:30	5.67	26.0	4.6	132.5	-9.9	11223100	.034	.001	.014	.001	2.4	29.0	-9.9	-9.9	17.9	11.3	.6	934	54.1
06:00:35	5.75	.4	4.6	128.8	-9.9	11223100	.034	.002	.013	.001	2.6	29.0	-9.9	-9.9	18.2	11.3	.7	955	51.1
06:00:40	5.83	26.2	4.6	131.4	-9.9	11223100	.034	-.001	.011	.000	2.6	29.0	-9.9	-9.9	17.9	11.0	.7	996	54.3
06:00:45	5.92	26.2	4.6	129.4	-9.9	11223100	.032	-.001	.013	.001	2.4	29.0	-9.9	-9.9	18.0	11.0	.7	1024	56.1
06:00:50	6.00	26.2	4.7	124.6	-9.9	11223100	.029	-.003	.019	.000	2.5	29.1	-9.9	-9.9	18.0	11.0	.7	1034	56.4
06:00:55	6.08	26.2	4.8	124.9	-9.9	11223100	.024	.001	.024	.001	2.4	29.1	-9.9	-9.9	18.2	11.0	.8	1050	53.7
06:01:00	6.17	26.2	4.9	122.3	-9.9	11223100	.021	.004	.022	.001	2.5	29.0	-9.9	-9.9	18.0	10.9	.7	1069	54.8
06:01:05	6.25	26.3	5.0	119.7	-9.9	11223100	.019	.005	.029	.001	2.5	28.9	-9.9	-9.9	18.2	11.0	.8	1089	53.4
06:01:10	6.33	26.3	2.0	121.7	-9.9	11223100	.017	.008	.030	.000	2.5	28.9	-9.9	-9.9	18.0	10.8	.7	1110	55.6
06:01:15	6.42	26.4	5.1	122.4	-9.9	11223100	.015	.008	.033	.001	2.7	28.9	-9.9	-9.9	18.2	10.9	.7	1135	53.8
06:01:20	6.50	26.4	5.2	120.8	-9.9	11223100	.014	.010	.034	.000	2.5	28.9	-9.9	-9.9	18.0	10.7	.7	1156	54.2
06:01:25	6.58	26.4	5.3	118.7	-9.9	11223100	.013	.010	.035	.001	2.5	28.9	-9.9	-9.9	18.2	10.9	.8	1174	55.3
06:01:30	6.67	26.5	5.4	117.8	-9.9	11223100	.012	.011	.038	.001	2.5	28.8	-9.9	-9.9	18.0	10.5	.8	1201	55.0
06:01:35	6.75	26.5	5.5	119.2	-9.9	11223100	.010	.010	.038	.001	2.5	28.8	-9.9	-9.9	18.3	10.5	.9	1230	54.6
06:01:40	6.83	26.5	5.6	116.1	-9.9	11223100	.009	.012	.039	.001	2.7	28.8	-9.9	-9.9	18.7	10.4	1.2	1257	53.9
06:01:45	6.92	26.6	.8	113.3	-9.9	11223100	.009	.015	.046	.001	2.6	28.8	-9.9	-9.9	19.4	10.7	1.5	1284	58.2
06:01:50	7.00	26.5	5.8	114.8	-9.9	11223100	.008	.017	.047	.045	2.8	28.7	-9.9	-9.9	19.5	10.5	2.3	1304	54.3
06:01:55	7.08	26.5	5.9	129.7	-9.9	11223100	.008	.017	.050	.080	2.7	28.8	-9.9	-9.9	19.6	9.5	4.1	1347	59.4
06:02:00	7.17	26.5	6.0	141.5	-9.9	11223100	.013	.010	.046	.130	2.7	28.9	-9.9	-9.9	19.7	9.0	1.9	1388	60.3
06:02:05	7.25	26.5	4.0	136.3	-9.9	11223100	.025	.007	.026	.001	2.5	28.9	-9.9	-9.9	19.2	7.2	.4	1425	62.7
06:02:10	7.33	26.4	6.0	132.4	-9.9	11223100	.035	.003	.013	.001	2.5	28.9	-9.9	-9.9	19.5	7.1	.4	1460	61.8
06:02:15	7.42	26.3	.4	122.4	-9.9	11223100	.041	-.001	.007	.000	2.5	28.9	-9.9	-9.9	19.3	7.2	.4	1487	63.7
06:02:20	7.50	26.2	6.0	127.6	-9.9	11223100	.043	-.000	.007	.001	2.6	29.0	-9.9	-9.9	19.3	7.4	.4	1517	65.8

TABLE C-6. FINAL DATA FILE FORMAT

HEADER RECORD 1 FORMAT

PARAMETER	CHARACTER	FORMAT	IDENTIFICATION
1	1	A1	Aircraft ID
2	2	I1	Year
3	3		Not used
4	4-6	I3	Julian date
5	7-10		Not used
6	11-15	A5	Parameter #1 ID (O_3)
7	16-20	A5	Parameter #2 ID (NO)
8	21-25	A5	Parameter #3 ID (NO_x)
9	26-30	A5	Parameter #4 ID (SO_2)
10	31-35	A5	Parameter #5 ID (CO)
11	36-40	A5	Parameter #6 ID (COT)
12	41-45	A5	Parameter #7 ID (CH_4)
13	46-50	A5	Parameter #8 ID (THC)

TABLE C-6. (Continued)

HEADER RECORDS 2 AND 3 FORMAT

PARAMETER	CHARACTERS ON RECORDS 2 & 3	FORMAT	RECORD 2 (PARAMETER)	RECORD 3 (UNITS)	LOCATION OF PARAMETER
1	1-5	A5	DME 1	NMILES	19-22
2	6-10	A5	DME 2	NMILES	23-26
3	11-15	A5	VOR	DEG	27-29
4	16-20	A5	HEAD	DEG	30-34
5	21-25	A5	-	-	70-73
6	26-30	A5	ALT	FEET	74-77
7	31-35	A5	ASPD	KNOTS	78-82
8	36-40	A5	TEMP	DEG C	83-87
9	41-45	A5	DPT	DEG C	88-92
10	46-50	A5	B_{SCAT}	1/M	93-96
11	51-55	A5	O_3	PPM	97-105
12	56-60	A5	NO	PPM	106-114
13	61-65	A5	NO_x	PPM	115-123
14	66-70	A5	SO_2	PPM	124-132
15	71-75	A5	CO	PPM	133-141
16	76-80	A5	CO T	DEG C	142-150
17	81-85	A5	CH_4	PPM	151-159
18	86-90	A5	NMHC	PPM	160-168

TABLE C-6. (Continued)

DATA RECORDS FORMAT

PARAMETER	CHARACTER	FORMAT	IDENTIFICATION
1	1	A1	Aircraft ID
2	2	I1	Year
3	3	-	(not used)
4	4-6	I3	Julian Date
5	7-8	I2	Hours
6	9-10	I2	Minutes
7	11-12	I2	Seconds
8	13-18	F6.2	Elapsed Time
9	19-22	F4.1	DME 1
10	23-26	F4.1	DME 2
11	27-29	I3	VOR
12	30-34	F5.1	Heading
13	35	I1	Flight Status
14	36-39	-	(not used)
15	40	A1	DME 1 CODE
16	41-44	-	(not used)
17	45	A1	DME 2 CODE
18	46-49	-	(not used)
19	50	A1	VOR CODE
20	51-54	A4	Activity Thumbwheels
21	55-56	A2	Bag Sample No.
22	57-58	-	(not used)
23	59-65	A7	Instrument Range
24	66-73	-	(not used)
25	74-77	I4	Altitude (feet)
26	78-82	F5.1	Airspeed
27	83-87	F5.1	Temperature
28	88-92	F5.1	Dewpoint
29	93-96	F4.1	B_{scat} (Nephelometer)
30	97-105	E9.3	O_3
31	106-114	E9.3	NO
32	115-123	E9.3	NO_x
33	124-132	E9.3	SO_2
34	133-141	E9.3	CO
35	142-150	E9.3	CO Temperature
36	151-159	E9.3	CH_4
37	160-168	E9.3	NMHC

"Location of parameter" refers to the field occupied by a parameter value on a data record.

APPENDIX D

USERS GUIDE TO RAMS SUPPORT MISSIONS

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TABLE D-1. REGIONAL AIR MONITORING STATION (RAMS) LOCATIONS

Station	Latitude	Longitude
101	N 38°38'08"	W 90°11'41"
102	38°38'30"	90°12'42"
103	38°41'29"	90°09'17"
104	38°39'42"	90°09'35"
105	38°36'18"	90°12'05"
106	38°36'59"	90°15'32"
107	38°36'41"	90°14'23"
108	38°39'08"	90°08'32"
109	38°44'57"	90°03'41"
110	38°37'17"	90°09'45"
111	38°34'14"	90°15'32"
112	38°38'52"	90°18'43"
113	38°43'37"	90°15'55"
114	38°47'38"	90°11'13"
115	38°47'00"	90°03'25"
116	38°43'20"	89°58'39"
117	38°34'03"	90°00'34"
118	38°29'11"	90°12'48"
119	38°33'20"	90°21'48"
120	38°41'44"	90°26'06"
121	38°50'29"	90°19'20"
122	39°05'00"	90°12'08"
123	38°41'05"	89°48'53"
124	38°15'00"	90°08'53"
125	38°40'08"	90°43'15"

TABLE D-2. SPIRALING LOCATIONS NOT OVER RAMS SITES

Location No.		Latitude	Longitude
105		N 38°35'24"	W 90°11'18"
106		38°38'18"	90°16'30"
113		38°44'07"	90°17'00"
41		38°30'36"	89°49'00"
42		38°28'00"	90°03'06"
43		38°26'30"	90°16'30"
44		38°34'00"	90°13'00"
141		38°37'43"	90°12'33"
142		38°31'15"	90°35'56"
143		38°25'32"	90°01'06"
31	(Smartt Field)	38°56'00"	90°26'00"
32	(Smartt Field)	38°56'00"	90°26'00"

TABLE D-3. VORTAC RADIO NAVIGATION STATION LOCATIONS

Station	Name	Latitude	Longitude	UTM*
1	Troy	38°44'21"	89°55'07"	16SBT465913
2	St. Louis	38°51'38"	90°28'56"	15SYP185042
3	Maryland Heights	38°40'38"	90°37'30"	15SYN067830
4	Scott AFB	38°34'20"	89°53'08"	16SBT487728

*Universal Transverse Mercator Grid Coordinates.

TABLE D-4. DESCRIPTION OF RAMS SUPPORT MISSIONS

The flight patterns for all seven RAMS support missions are described below. A corresponding figure, a map of the St. Louis, Missouri/Illinois Metropolitan area, including the RAMS stations, shows the route taken by the helicopter. It should be noted that the spiral locations for sites 105, 106 and 113 were not over the RAMS stations. The spiral for site 105 was over an open field across the Mississippi River, as indicated on the figures. The spiral for site 106 was done over open athletic fields in Forest Park as shown in the figures. The spiral for site 113 was done over a golf course at a point just east of the indicated RAMS site. The latitude and longitude of these sites are listed in Table D-1. Also listed are coordinates of additional special spiral sites not associated with the RAMS sites (Table D-2).

JULY-AUGUST 1974

Three tracks were devised for RAMS support during the July-August exercise. These were designated Tracks 1, 5, and 7.

Track 1. Scott AFB to site 118, to site 105, to site 106, to site 103, to site 113, a stop at Lambert Field for refueling, to site 121, to site 108, to site 115, to site 123, and return to Scott AFB. Later in the exercise as the pilots became more familiar with the area and the aircraft, more fuel was carried and the refueling stop at Lambert was eliminated. Track 1 is shown in Figure D-1.

Track 5. Scott AFB to site 125, to site 105, to site 103, to site 123, and return to Scott AFB. Track 5 is shown in Figure D-2.

Track 7. Scott AFB to site 117, to site 118, to site 106, to site 103, to site 102, to site 108, to site 115, to site 116, and return to Scott AFB. Track 7 is shown in Figure D-3.

NOVEMBER-DECEMBER 1974

Two tracks were used for this field exercise. They are designated in the flight records as Track Red and Track Blue.

Track Red. Scott AFB to site 118, to site 119, to site 103, to site 102, to site 113, to site 121, to site 114, to site 108, to site 109, and return to Scott AFB. Track Red is shown in Figure D-4.

Track Blue. Scott AFB to site 117, to site 105, to site 120, to site 121, to site 115, to site 116, to site 123, and return to Scott AFB. Track Blue is shown in Figure D-5.

(Continued)

TABLE D-4. (Continued)

FEBRUARY-MARCH 1975

Nine tracks were used during the February-March 1975 exercise. The flight patterns were designed to provide flux information along the North-South, East-West, Northeast-Southwest, and Northwest-Southeast lines. Two patterns were used for each direction, except for the East-West pattern, which required three flight patterns.

The nine flight patterns were for particular wind patterns, i.e., when the wind was from the North, the North-South patterns were flown. However, when the wind was from the opposite direction, the flight pattern was reversed and the mission log would indicate a South-North pattern.

North-South A. Scott AFB to site 123, to site 116, to site 115, to site 114, to site 121, to site 113, to site 102, to site 105, to site 118, and return to Scott AFB. Pattern North-South is shown in Figure D-6.

North-South B. Scott AFB to site 114, to site 113, to site 102, to site 105, to site 118, to site 43, to site 119, to site 44, and return to Scott AFB. Sites 43 and 44 were spiral sites over open fields to augment the information being obtained from the RAMS stations. The locations of these sites are shown with the rest of the flight pattern in Figure D-7.

Northeast-Southwest A. Scott AFB to site 123, to site 115, to site 121, to site 108, to site 102, to site 119, to site 105, and return to Scott AFB. Pattern Northeast-Southwest A is shown in Figure D-8.

Northeast-Southwest B. Scott AFB to site 103, to site 102, to site 106, site 120, to site 36, to site 119, to site 118, to site 43, and return to Scott AFB. Site 36 was a St. Louis County monitoring pattern in Figure D-9.

Northwest-Southeast A. Scott AFB to site 106, to site 120, to site 121, to site 113, to site 103,to site 116, to site 118, and return to Scott AFB. This flight pattern is shown in Figure D-10.

Northwest-Southeast B. Scott AFB to site 106, to site 103, to site 105, to site 109, to site 117, to site 118, to site 42, to site 41. Sites 41 and 42 were spiral locations chosen to augment the information obtained over the RAMS network. Site 41 was over an open field, approximately 1 kilometer north of the town of Freeburg, and site 42 was over an open field immediately north of Roachtown. All of the spiral locations are shown in Figure D-11.

East-West A. Scott AFB to site 121, to site 120, to site 125, to site 119, and return to Scott AFB. The East-West A pattern is shown in Figure D-12.

(Continued)

TABLE D-4. (Continued)

East-West B. Scott AFB to site 115, to site 108, to site 103, to site 105, to site 118, to site 106, and return to Scott AFB. This pattern is shown in Figure D-13.

East-West C. Scott AFB to site 40, to site 123, to site 117, to site 109, to site 103, to site 105, to site 106, and return to Scott AFB. Site 40 was near the town of Mascoutah, Illinois, and is shown with the rest of the spiral sites in Figure D-14.

JULY-AUGUST 1975

Four basic patterns were used during the July-August 1975 exercise. However, during the course of the study, the patterns were modified to supply more information. By the end of the exercise, 16 patterns had been flown.

North-South. Smartt Field to site 122, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The North-South pattern is shown in Figure D-15.

East-West. Smartt Field to site 123, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The South-North pattern is shown in Figure D-16.

South-North. Smartt Field to site 124, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The South-North pattern is shown in Figure D-17.

West-East. Smartt Field to site 125, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The West-East pattern is shown in Figure D-18.

North-South Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 122, and return to Smartt Field. The North-South Final pattern is shown in Figure D-19.

East-West Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 123, and return to Smartt Field. The East-West Final pattern is shown in Figure D-20.

South-North Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 124, and return to Smartt Field. The South-North Final pattern is shown in Figure D-21.

West-East Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 125, and return to Smartt Field. The West-East Final pattern is shown in Figure D-22.

(Continued)

North-South Double. Smartt Field to site 122, to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The North-South Double pattern is shown in Figure D-23.

East-West Double. Smartt Field to site 123, to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The East-West Double pattern is shown in Figure D-24.

South-North Double. Smartt Field to site 124, to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The South-North Double pattern is shown in Figure D-25.

West-East Double. Smartt Field to site 125, to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, and return to Smartt Field. The West-East Double pattern is shown in Figure D-26.

North-South Double Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, to site 122, and return to Smartt Field. This pattern is shown in Figure D-27.

East-West Double Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to 106, to site 105, to site 123, and return to Smartt Field. This pattern is shown in Figure D-28.

South-North Double Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, to site 124, and return to Smartt Field. This pattern is shown in Figure D-29.

West-East Double Final. Smartt Field to site 102, to site 103, to site 106, to site 105, to site 102, to site 103, to site 106, to site 105, to site 125, and return to Smartt Field. This pattern is shown in Figure D-30.

FEBRUARY-MARCH 1976

Some of the same flight patterns were used as in the July-August 1975 field exercises. However, a different nomenclature was used to describe the pattern. Also, five new patterns were used. When patterns were repeated during the day they were numbered in sequence, for example North 1, North 2, and North 3.

(Continued)

TABLE D-4. (Continued)

The nomenclature used in the July-August 1975 exercise is given below with the February-March equivalents and Figures showing the patterns.

North-South = North 1 or North 2 or North 3 = Figure D-15.

North-South Double = North 1 & 2, or North 3 & 4 = Figure D-23.

North-South Double Final = North 4 = Figure D-27.

East-West = East 1 or East 2 or East 3 = Figure D-16.

East-West Double = East 1 & 2 or East 3 & 4 = Figure D-26.

East-West Double Final = East 4 = Figure D-28.

South-North = South 1 or South 2 or South 3 = Figure D-17.

South-North Double = South 1 & 2 or South 3 & 4 = Figure D-25.

South-North Double Final = South 4 = Figure D-29.

West-East = West 1 or West 2 or West 3 = Figure D-18.

West-East Double = West 1 & 2 or West 3 & 4 = Figure D-26.

West-East Double Final = South 4 = Figure D-30.

All five new patterns used during the February-March 1976 exercise fell into the general category of "Upwind Background Flights," also called "Crosswind Flights." Each of these flights used a single "upwind" RAMS site as its focus. The upwind sites for the patterns were:

West Upwind Background (crosswind) = RAMS site 125

South Upwind Background (crosswind) = RAMS site 124

East Upwind Background (crosswind) = RAMS site 123

North Upwind Background (crosswind) = RAMS site 122

Southeast Upwind Background (crosswind) = RAMS site 117

Each of the "Upwind Background" patterns followed a common practice of flying to the upwind site at 1,000 feet MSL from Smartt Field. At the site, a right turn was made (90° to the wind direction) and the helicopter flew out from the site for 10 nautical miles at 1,000 feet MSL. At the end of the

(Continued)

TABLE D-4. (Continued)

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10 nautical mile leg, the helicopter ascended to 2,000 feet MSL and flew back to the site. The helicopter then spiraled down 1,000 feet MSL and the helicopter flew out from the site 10 nautical miles in the opposite direction to the first leg, 270° to the wind direction. At the end of this leg, the helicopter ascended to 2,000 feet MSL to return to the site where it spiraled down to 200 feet AGL. The helicopter ascended to 1,000 feet MSL and again flew a 10 nautical mile leg at 90° to the wind direction. The pattern was repeated as many times as time would allow, and then the helicopter returned to Smartt Field. These patterns are depicted in Figures D-31 through D-35.

JULY-AUGUST 1976

This field exercise used the same flight patterns as described under the February-March exercise plus the addition of one new pattern. The new pattern was a "Downwind Pattern" designed to examine the pollution concentrations over the RAMS site furthermost downwind. The pattern was described as a West Downwind Final and the helicopter flew from Smartt Field to site 102, to site 103, to site 106, to site 105, to site 123, and returned to Smartt Field. This pattern is shown in Figure D-36.

OCTOBER-NOVEMBER 1976

The same "Double" patterns used during the Summer RAPS 1975 missions were used during the first week of operations. During the second week and for the rest of the exercise, six of the eight "double" patterns were modified slightly to include flight legs to measure the upwind concentration. These legs were flown in a similar pattern to the background flights described above. The South-North Double and the South-North Double Final were not modified because the flight times were too long to allow additional flying. The remaining double pattern covered the same RAMS sites and in the same order as those during the Summer RAPS 1975 exercise.

The West-East Double Background Pattern is shown in Figure D-37.

The East-West Double Background Pattern is shown in Figure D-38.

The North-South Double Background Pattern is shown in Figure D-39.

The West-East Double Final Background Pattern is shown in Figure D-40.

The East-West Double Final Background Pattern is shown in Figure D-41.

The North-South Double Final Background Pattern is shown in Figure D-42.

TABLE D-5. USERS GUIDE TO RAMS SUPPORT MISSIONS

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
8/13/74 4225	Track 1	I	0635 1040	
8/14/74 4226	Track 1	I	0900 1144	
8/14/74 4226	Track 1	I	1411 1654	
8/15/74 4227	Wood River Refinery	I	0818 0945	Special Study See Table E-1
8/15/74 4227	Track 1	I	1116 1354	
8/16/74 4228	St. Louis Pt. Sources	I	0820 0945	Special Study See Table E-1
8/16/74 4228	Track 5	I	1100 1308	
8/19/74 4231	Track 7	II	0650 0810	
8/19/74 4231	Track 7	II	0930 1035	
8/19/74 4231	Track 1	II	1230 1325	
8/19/74 4231	Track 7	I	1417 1604	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
8/20/74 4232	Track 1	I	0704 1032	
8/20/74 4232	RAMS Site 103	II	1400 1645	Special Study See Table E-1
8/21/74 4233	Track 7	I	0626 0810	
8/21/74 4233	Track 1	II	0842 1227	
8/21/74 4233	Track 5	II	1351 1522	
8/22/74 4234	Track 7	II	0634 0836	
8/22/74 4234	Track 1	I	0653 0908	
8/26/74 4238	Track 1	II	0938 1221	
8/26/74 4238	Track 5	I	1440 1646	
8/26/74 4238	Track 1	II	1531 1720	
8/27/74 4239	Track 1	II	0634 0840	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
8/27/74 4239	Track 7	II	0957 1140	
11/12/74 4316	Blue Track	I	0840 1040	
11/12/74 4316	Blue Track	I	1314 1510	
11/14/74 4318	Blue Track	I	0736 1005	
11/14/74 4318	Blue Track	I	1132 1318	
11/15/74 4319	Blue Track	I	1149 1424	
11/16/74 4320	Red Track	I	0800 1030	
11/16/74 4320	Red Track	I	1142 1400	
11/20/74 4324	Blue Track	II	0713 0934	
11/20/74 4324	Blue Track	II	1145 1401	
11/21/74 4325	Blue Track	I	0739 0957	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
11/21/74 4325	Blue Track	II	1002 1207	
11/21/74 4325	Blue Track	I	1150 1425	
11/21/74 4325	Blue Track	II	1350 1558	
11/22/74 4326	Red Track	I	1313 1546	
11/23/74 4327	Red Track	I	0939 1142	
11/25/74 4329	Red Track	I	0735 1013	
11/25/74 4329	Red Track	I	1219 1452	
11/25/74 4329	Red Track	II	1446 1646	
11/26/74 4330	Red Track	I	0729 0851	
11/26/74 4330	Red Track	II	0925 1143	
11/26/74 4330	Red Track	II	1256 1540	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
11/26/74 4330	Red Track	I	1455 1644	
11/27/74 4331	Blue Track	I	0730 1002	
11/27/74 4331	Blue Track	II	0937 1136	
11/27/74 4331	Blue Track	I	1119 1320	
11/27/74 4331	Blue Track	II	1415 1626	
11/28/74 4332	Red Track	I	0718 0930	
11/28/74 4332	Blue Track	I	1005 1225	
11/28/74 4332	Red Track	I	1342 1628	
12/2/74 4336	Red Track	I	0807 1025	
12/2/74 4336	Red Track	II	1019 1211	
12/2/74 4336	Red Track	I	1305 1551	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
12/3/74 4337	Blue Track	II	0711 0925	
12/3/74 4337	Blue Track	II	1401 1542	
12/4/74 4338	Baldwin, IL Power Plant Plume	II	1051 1250	Special Study See Table E-1
12/3/74 4338	Blue Track	III	1204 1414	
12/3/74 4338	Blue Track	II	1401 1605	
12/5/74 4339	Red Track	III	0725 0949	
12/5/74 4339	Red Track	II	0937 1136	
12/5/74 4339	Red Track	III	1204 1425	
12/5/74 4339	Red Track	II	1358 1537	
12/5/74 4339	Square Track	III	1616 1715	Special Track
12/6/74 4340	Red Track	II	0712 0918	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
12/6/74 4340	Red Track	III	0857 1115	
12/6/74 4340	Square Track	II	1105 1247	Special Track
2/3/75 5034	Northeast-Southwest	III	0838 1100	
2/3/75 5034	Northeast-Southwest	III	1326 1521	
2/6/75 5037	Northwest-Southeast	II	1310 1610	
2/7/75 5038	East-West-A	II	0731 0927	
5/7/75 5088	East-West-B	I	0842 1039	
5/7/75 5088	East-West-C	II	1046 1234	
2/8/75 5039	Northwest-Southeast	I II	0855 1130	Two tapes Parallel flights
2/9/75 5040	Northwest-Southeast	II	0836 1053	
2/9/75 5040	Northwest-Southeast	I	0920 1133	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
2/9/75 5040	Northwest-Southeast	I II	1340 1550	Two tapes Parallel flights
2/10/75 5041	South-North	I	0738 1002	
2/10/75 5041	South-North	II	0800 1030	
2/10/75 5041	South-North	II	1300 1440	
2/10/75 5041	South-North	I	1304 1510	
2/12/75 5043	Northwest-Southeast	II	0823 1031	O_3 Inoperative
2/12/75 5043	Northwest-Southeast	II	1203 1402	O_3 Inoperative
2/13/75 5044	Northeast-Southwest	II	0852 1046	O_3 Inoperative
2/13/75 5044	Northeast-Southwest	I	0918 1123	
2/13/75 5044	Southeast-Northwest	II	1301 1438	
2/13/75 5044	Southeast-Northwest	I	1402 1614	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
2/17/75 5048	West-East	I	0900 1045	
2/17/75 5048	West-East	I	1046 1221	
2/17/75 5048	West-East	II	1115 1420	
2/17/75 5048	West-East	I	1420 1530	
2/17/75 5048	West-East	I	1530 1640	
2/18/75 5049	Southwest-Northeast	II	0721 0913	
2/19/75 5050	Northwest-Southeast	II	0716 0916	
2/19/75 5050	Baldwin, IL Power Plant Plume	II	1148 1557	Special Study See Table E-1
2/20/75 5051	Background Flight	I	0730 1130	
2/20/75 5051	Southwest-Northeast	II	0739 0912	
2/20/75 5051	Background Flight	II	1034 1334	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Helicopter No.	Time Period (CST)	Comments
2/20/75 5051	Southwest-Northeast	I	1250 1451	
2/21/75 5052	Alton Area Spirals	II	1403 1616	Special Study
2/26/75 5057	Northwest-Southeast Double	II	0659 0852	
2/26/78 5057	Northwest-Southeast Double	II	0853 1008	
2/26/75 5057	Northwest-Southeast Double	I	0715 1052	
2/26/75 5057	Northwest-Southeast Double	II	1037 1335	
2/27/75 5058	Baldwin, IL Power Plant Plume	II	0648 0939	Special Study See Table E-1
2/27/75 5058	North-South	II	1212 1351	O_3 Inoperative
2/28/75 5059	Northwest-Southeast	II	0753 1012	
2/28/75 5059	Northwest-Southeast	I	0854 1053	O_3 Inoperative
2/28/75 5059	Northwest-Southeast	II	1214 1406	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
3/1/75 5060	Labadie Plume Study	II	0902 1230	Special Study See Table E-1
3/2/75 5061	Northwest-Southeast	I	0757 0932	
3/4/75 5063	North-South Double	I	0630 0953	
3/4/75 5063	North-South Double	II	0700 0954	
3/4/75 5063	North-South Double	I	1151 1446	
3/4/75 5063	North-South Double	II	1215 1605	
3/5/75 5064	Southwest-Northeast	I	0655	NO and NO_X Inoperative
3/5/75 5064	Southwest-Northeast Double	II	0657 1053	
3/5/75 5064	Southwest-Northeast Double	II	1247 1603	
7/14/75 5195	West-East	III	0716 0930	
7/14/75 5195	West-East	I	0800 1017	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
7/14/75 5195	West-East	I	1109 1254	
7/14/75 5195	West-East Double	III	1100 1300	
7/15/75 5196	West-East Double	I	0758 1027	
7/15/75 5196	West-East Double	III	1100 1416	
7/15/75 5196	Oxidant Max Study	I	1410 1645	Special Study See Table E-1
7/16/75 5197	South-North	III	0705 0845	
7/16/75 5197	South-North	I	0810 1002	
7/16/75 5197	South-North	I	1117 1250	
7/16/75 5197	South-North	III	1215 1434	
7/17/75 5198	West-East	III	0700 0910	
7/17/75 5198	West-East	I	0806 0949	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
7/17/75 5198	West - East	III	1109 1315	
7/17/75 5198	West - East	I	1242 1342	
7/18/75 5199	South - North Double	III	0700 1000	
7/18/75 5199	Oxidant Max Study	I	0829 1130	Special Study See table E-1
7/18/75 5199	West - East Double	III	1126 1404	
7/18/75 5199	Oxidant Max Study	I	1239 1526	Special Study See table E-1
7/19/75 5200	West - East	III	0707 0910	
7/19/75 5200	West - East	I	0810 0959	
7/19/75 5200	West - East	I	1107 1252	
7/19/75 5200	West - East	III	1226 1411	
7/22/75 5203	East - West	III	0658 0850	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
7/22/75 5203	East - West	I	0805 0956	
7/22/75 5203	South - North	III	1124 1330	
7/22/75 5203	South - North	I	1200 1525	
7/23/75 5204	South - North	III	0706 0930	
7/23/75 5204	South - North	I	0807 1023	
7/23/75 5204	South - North Double	I	1220 1545	
7/24/75 5205	West - East Double	III	0701 1004	NO and NO_x inoperative
7/24/75 5205	North - South Double	I	1104 1430	SO_2 inoperative
7/24/75 5205	Station 108 Spirals	III	1330 1615	Special Study See table E-1
7/25/75 5206	North - South	III	0715 0929	
7/25/75 5206	North - South	I	0800 1010	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
7/25/75 5206	North - South Double	III	1102 1334	
7/25/75 5206	Oxidant Max Study	I	1340 1545	Special Study See table E-1
7/26/75 5207	East - West	III	0704 0928	
7/26/75 5207	East - West	I	0812 1025	
7/26/75 5207	East - West Double	III	1111 1403	
7/27/75 5208	West - East Double	II	0824 1054	
7/27/75 5208	West - East Double	III	1105 1350	
7/28/75 5209	West - East Double	III	0700 0948	
7/28/75 5209	North - South Double	III	1312 1538	
7/29/75 5210	North - South	III	0708 0918	
7/29/75 5210	East - West Double	III	1246 1535	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
7/30/75 5211	East - West Double	III	1103 1230	
7/30/75 5211	Sulfur Transformation Study	II	1107 1440	Special Study See table E-1
7/31/75 5212	East - West Double	II	0750 1005	
7/31/75 5212	East - West Double	II	1157 1423	
8/3/75 5215	North - South Double	I	1100 1340	
8/3/75 5215	Oxidant Max Study	II	1248 1457	Special Study See table E-1
8/4/75 5216	Labadie Plume Study	I	0638 1031	Special Study See table E-1
8/5/75 5217	Labadie Plume Study	II	0717 1044	Special Study See table E-1
8/5/75 5217	Labadie Plume Study	II	1210 1510	Special Study See table E-1
8/6/75 5218	North - South Double	I	1158 1422	
8/6/75 5218	Oxidant Maximum Study	II	1230 1440	Special Study See table E-1
8/7/75 5219	Helicopter Parallel Flight	I, II	0719 0816	Two Tapes

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
8/8/75 5220	South-North Double	I	0720 1022	
8/10/75 5222	West-East Double	II	1100 1332	
8/11/75 5223	West-East Double	II	0630 0930	
8/12/75 5224	West-East Double	II	0708 0943	
8/12/75 5224	West-East Double	II	1110 1350	
2/14/76 6045	East-West Double	III	0709 1004	SO_2 Inoperative
2/14/76 6045	South-North Double	III	1200 1600	SO_2 Inoperative
2/15/76 6046	South-North Double	III	0715 1034	
2/17/76 6048	East-West	III	0700 1000	
2/19/76 6050	West-East Double	III	0707 1014	
2/19/76 6050	West-East	III	1210 1400	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
2/20/76 6051	South-North Double	III	0711 1113	
2/21/76 6052	South-North	III	1056 1400	
2/22/76 6053	North-South	III	0710 0852	
2/22/76 6053	Temperature Profile	III	1600 1800	Special Study See Table E-1
2/23/76 6054	Temperature Profile	I	0514 0914	Special Study See Table E-1
2/23/76 6054	Special Spirals Temperature Profile	I	1549 1750	Special Study See Table E-1
2/24/76 6055	Temperature Profile	I	0700 1000	Special Study See Table E-1
2/26/76 6057	Parallel Flights	I	1106 1817	Special Flights Three Tapes
2/27/76 6058	West-East	I	0738 0950	
2/28/76 6059	East-West Double	III	0803 1140	
3/1/76 6061	South-North Double	III	0710 1130	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
3/1/76 6061	South-North	III	1209 1336	
3/6/76 6066	Temperature Profiles	III	0644 2300	Special Study See Table E-1 7 Tapes
3/7/76 6067	Temperature Profiles	III	0634 1200	Special Study See Table E-1 3 Tapes
3/9/76 6069	North-South Background	I	0727 1049	
3/9/76 6069	Spiral, Sta 103, 108	I	1314 1500	Special Flight
3/10/76 6070	West-East Double	I	0718 1021	
3/10/76 6070	West-East	I	1317 1528	
7/16/76 6198	West Upwind	I	0728 1003	
7/16/76 6198	North Upwind	II	0828 1109	
7/16/76 6198	North Upwind	I	1216 1512	
7/19/76 6201	South Upwind	I	0614 0941	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
7/19/76 6201	South Upwind	II	0719 1037	
7/20/76 6202	West Upwind	II	0616 0912	
7/20/76 6202	West Upwind	I	0723 1009	
7/23/76 6205	Project DaVinci	I	0433 0743	Special Study See Table E-1
7/23/76 6205	Project DaVinci	II	0545 0900	Special Study See Table E-1
7/23/76 6205	Project DaVinci	I	0833 1129	Special Study See Table E-1
7/29/76 6211	West Upwind	I	0613 0651	Flight Aborted
7/29/76 6211	Temperature Profiles	I	1731 2314	Special Study See Table E-1
7/30/76 6212	South Upwind	I	0619 0957	
7/30/76 6212	Temperature Profile	II	0826 1034	Special Study See Table E-1
7/30/76 6212	Temperature Profile	I	1120 1345	Special Study See Table E-1

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
7/30/76 6212	Parallel Flight	I II	1446 1625	Special Flight Two Tapes
8/1/76 6214	Temperature Profile	III	1052 1300	Special Flight See Table E-1
8/2/76 6215	Temperature Profile	II	0456 0657	Special Flight See Table E-1
8/2/76 6215	North Upwind	III	0806 1108	
8/2/76 6215	Southeast Upwind	III	1318 1613	
8/3/76 6216	Temperature Profile	II	0435 0635	Special Flight See Table E-1
8/3/76 6216	East Upwind	III	0559 0843	
8/3/76 6216	Temperature Profile	II	0730 0927	Special Flight See Table E-1
8/3/76 6216	East - West Double	III	1033 1318	
8/3/76 6216	East-West Double	II	1047 1313	
8/3/76 6216	East Upwind	II	1517 1748	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
8/4/76 6217	Temperature Profile	II	0504 0619	Special Study See Table E-1
8/4/76 6217	Temperature Profile	III	0806 1016	Special Study See Table E-1
8/4/76 6217	South-North Double	II	0735 1030	
8/6/76 6219	West Upwind	III	0620 0754	
8/7/76 6220	North Upwind	I	0604 0840	
8/07/76 6220	North Upwind	III	0708 0952	
8/07/76 6220	North Upwind	I	1102 1358	
8/07/76 6220	North Upwind	III	1207 1512	
8/8/76 6221	Temperature Profile	III	0430 0750	Special Study See Table E-1
8/8/76 6221	Portage-Des-Sioux Plume	I	0635 0930	Special Study See Table E-1
8/09/76 6222	South Upwind	I	1121 1324	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
8/10/76 6223	South Upwind	I	0642 0916	
8/11/76 6224	East Upwind	III	1217 1621	
8/12/76 6225	Portage-Des-Sioux Plume	I,III	0615 1500	Special Study See Table E-1,2 Tapes
8/13/76 6226	West Upwind	I	0658 0941	
8/13/76 6226	West Upwind	III	0729 1003	
10/26/76 6300	East-West Double	III	0555 0900	
10/26/76 6300	East-West Double Final	III	1030 1305	
10/27/76 6301	North-South Double	III	0600 0820	
10/27/76 6301	North-South Double	III	1015 1245	
10/28/76 6302	South-North Double	III	1050 1340	
10/28/76 6302	South-North Double	III	1330 1605	

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
10/29/76 6303	West-East Double Double	III	0700 0940	
10/29/76 6303	South-North Double	III	1115 1400	
11/1/76 6306	South-North Double Final	III	0850 1154	
11/1/76 6306	South-North Double	III	1348 1637	
11/2/76 6307	West-East Double Background	III	0710 0952	
11/2/76 6307	West-East Double Background	III	1131 1355	
11/3/76 6308	West-East Double Background	I	0715 1018	
11/3/76 6308	West-East Double Final Background	III	1145 1505	
11/4/76 6309	North-South Double Background	III	0716 1020	
11/4/76 6309	North-South Double Background	III	1144 1447	
11/5/76 6310	West-East Double Background	III	0707 1019	

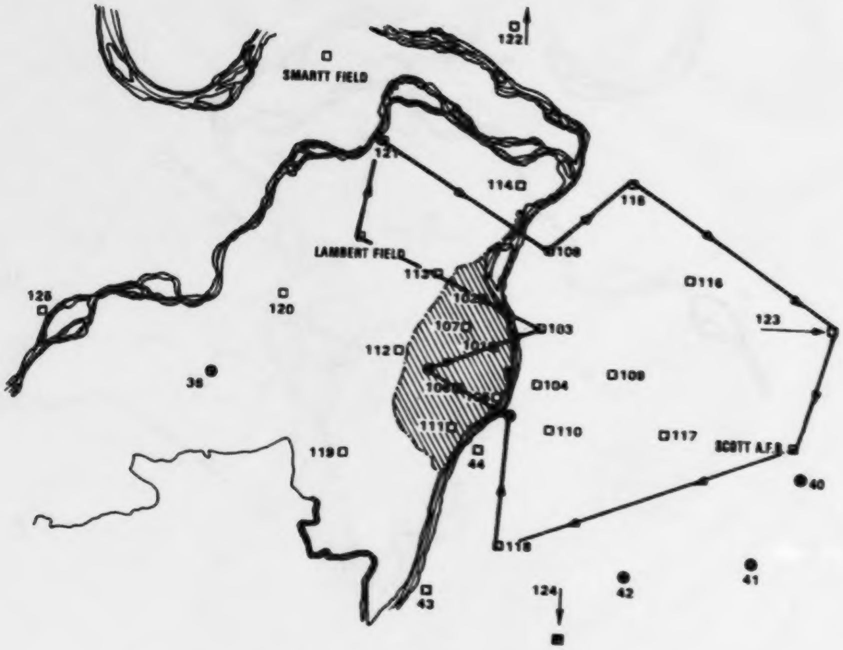
TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS

Date: Calendar Julian	Mission Description	Heli-copter No.	Time Period (CST)	Comments
11/6/76 6311	West-East Double Final Background	III	1230 1600	
11/8/76 6313	North-South Double Background	III	0650 0947	
11/8/76 6313	Labadie Plume Study	III	1227 1535	Special Study See Table E-1
11/9/76 6314	West-East Double Background	III	0810 1140	
11/9/76 6314	Labadie Plume Study	III	1245 1525	Special Study See Table E-1
11/10/76 6315	North-South Double Background	III	0807 1108	
11/10/76 6315	West-East Double Double Background	III	1219 1453	
11/11/76 6316	North-South Double Background	III	0656 1013	
11/11/76 6316	North-South Double Final Background	III	1115 1416	
11/12/76 6317	North-South Double Background	III	0648 1003	
11/12/76 6317	Labadie Plume Study	III	1130 1430	Special Study See Table E-1

TABLE D-5. (Continued)

HELICOPTER SUPPORT MISSIONS				
Date: Calendar Julian	**Mission Description**	**Heli-copter No.**	**Time Period (CST)**	**Comments**
11/15/76 6320	North-South Double Background	III	0649 1009	
11/15/76 6320	East-West Double Final Background	III	1115 1416	
11/16/76 6321	South-North Double	III	0706 0959	
11/16/76 6321	South-North Double Final	III	1104 1356	
11/17/76 6322	West-East Double Background	III	0923 1239	
11/17/76 6322	West East Double Final Background	III	1325 1603	
11/18/76 6323	West-East Double Background	III	0700 1025	
11/18/76 6323	West-East Double Final Background	III	1141 1500	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SCOTT A.F.B.
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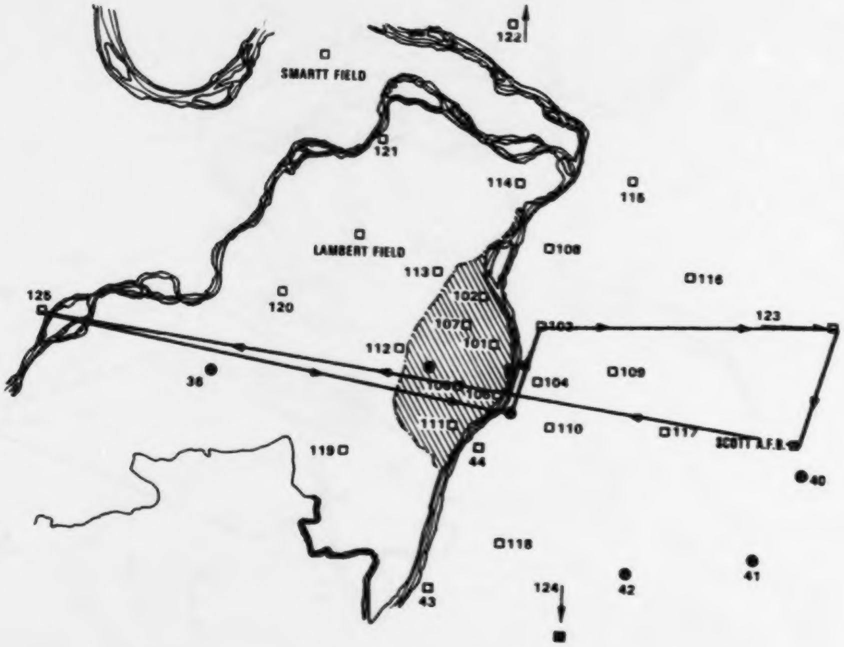
Figure D-1. RAMS Network - Track 1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SCOTT A.F.B.
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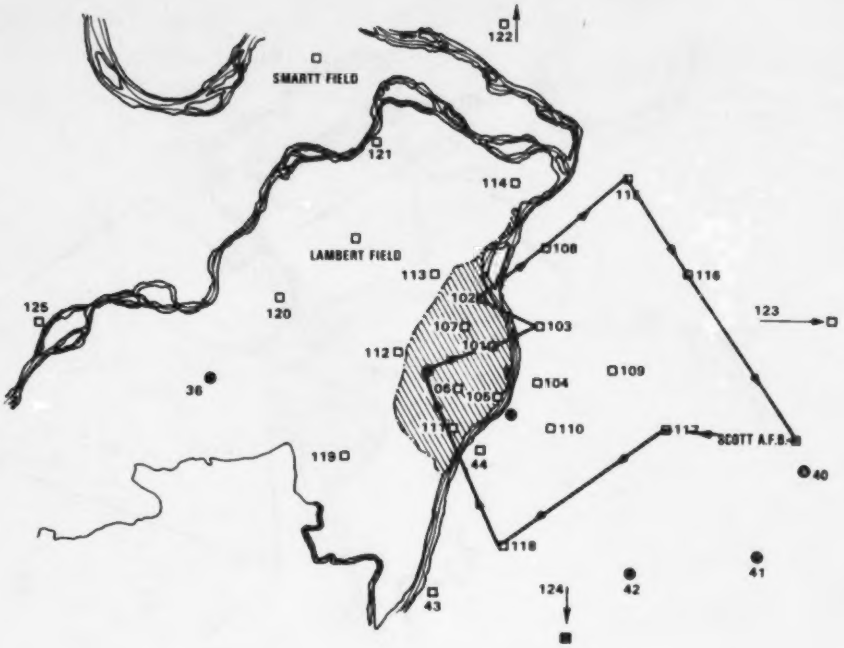
Figure D-2. RAMS Network - Track 5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SCOTT A.F.B.
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118
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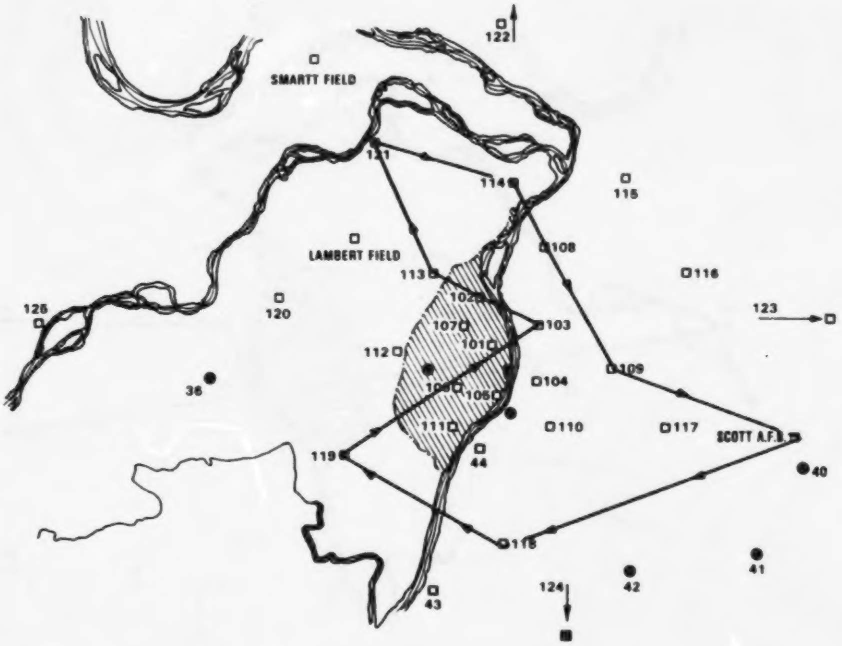
Figure D-3. RAMS Network - Track 7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SCOTT A.F.B.
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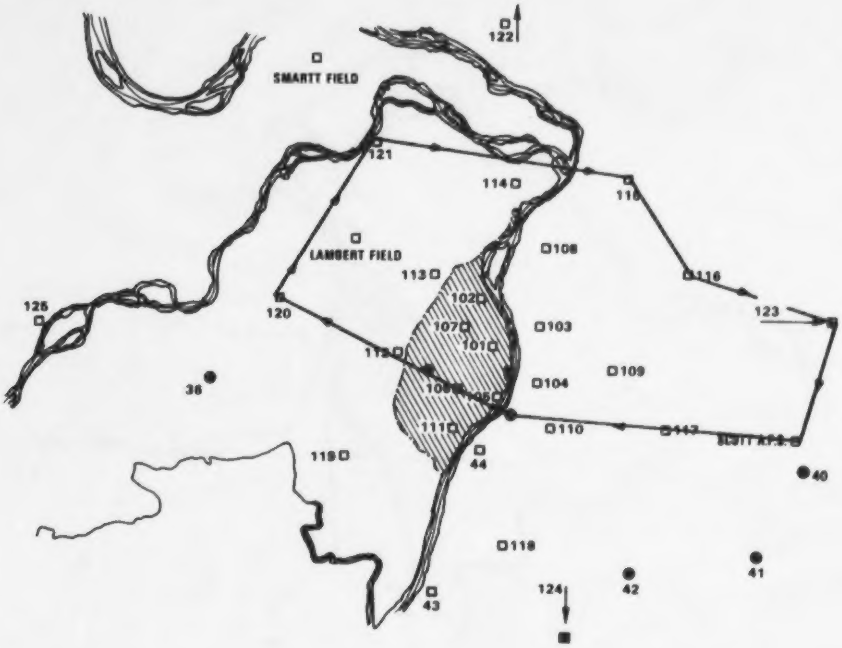
Figure D-4. RAMS Network - Track Red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SCOTT A.F.B.
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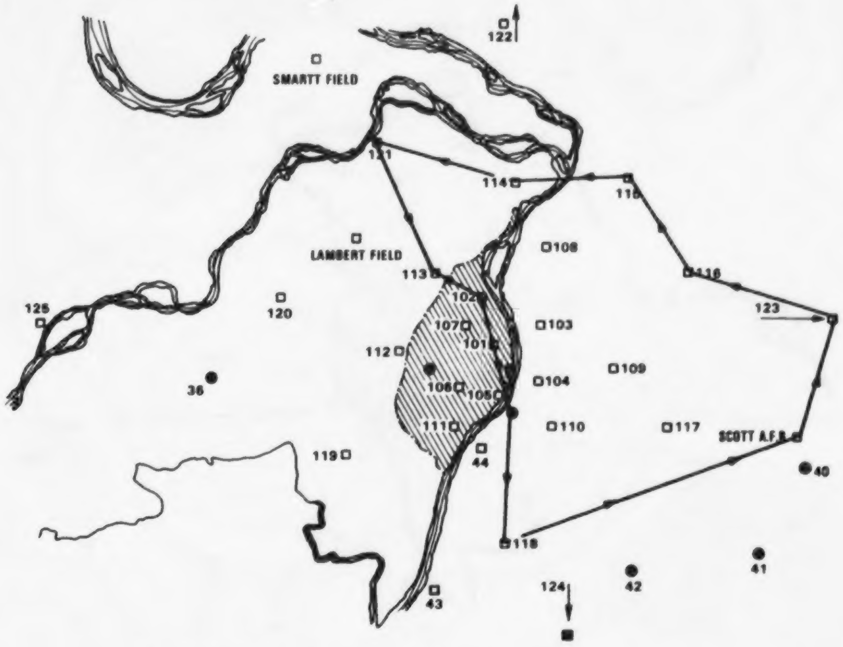
Figure D-5. RAMS Network - Track Blue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SCOTT A.F.B.
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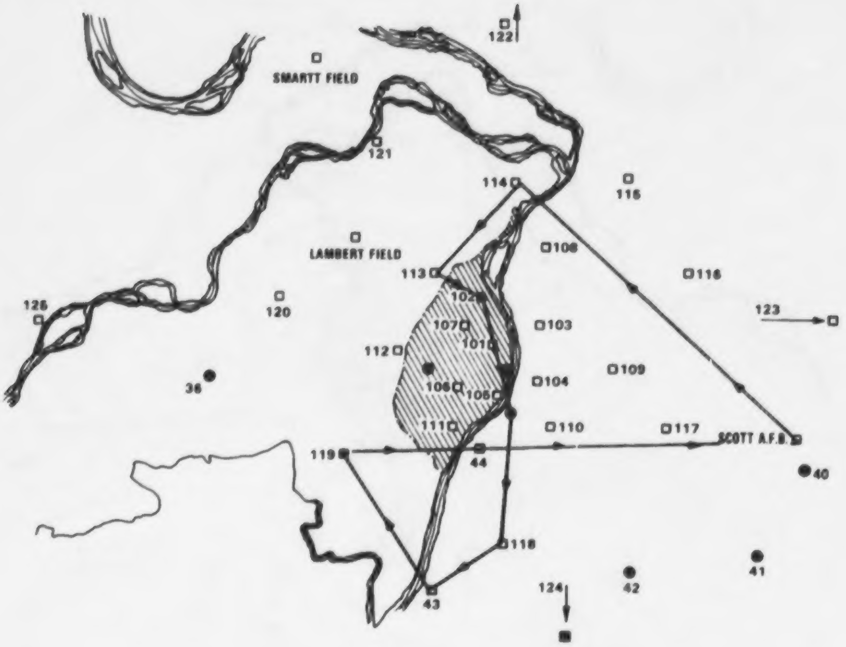
Figure D-6. RAMS Network - North-South A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SCOTT A.F.B.
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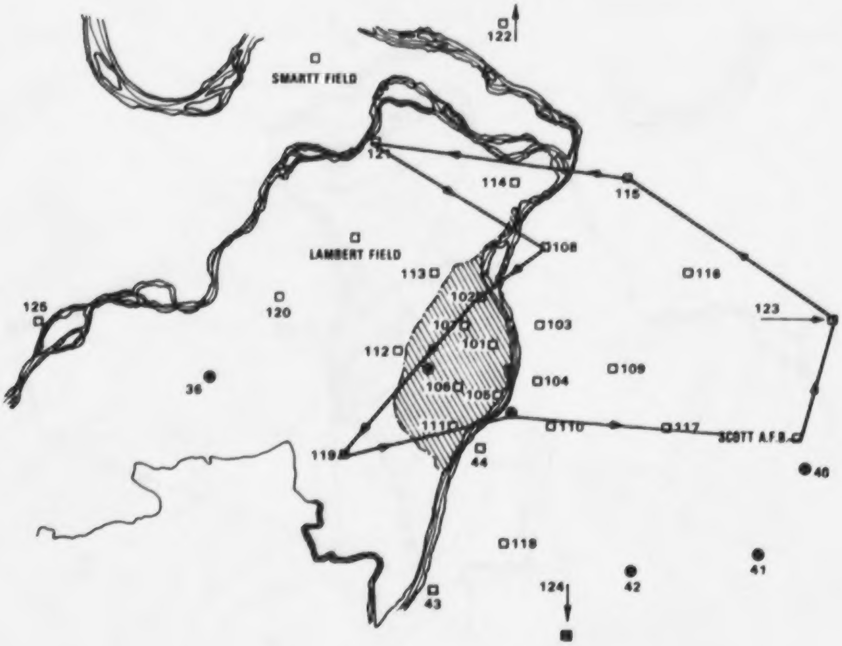
Figure D-7. RAMS Network - North-South B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SCOTT A.F.B.
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Figure D-8. RAMS Network - Northeast-Southwest A

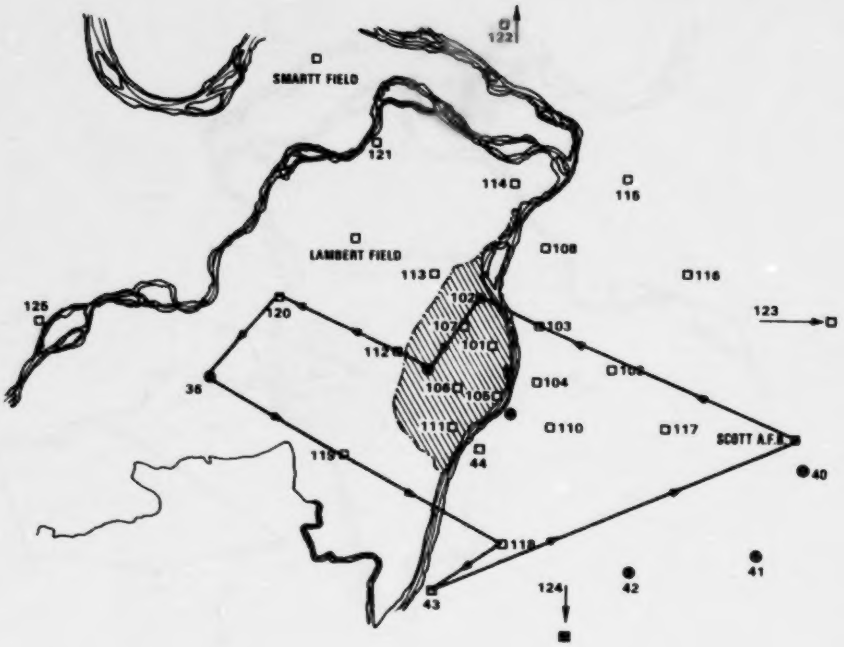
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Figure D-9. RAMS Network - Northeast-Southwest B

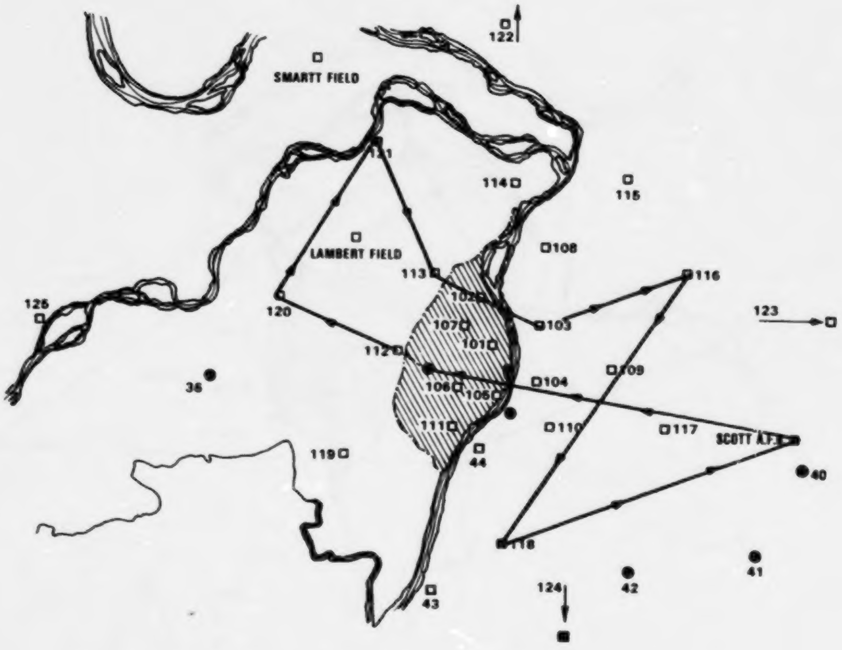
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Figure D-10. RAMS Network - Northwest-Southeast A

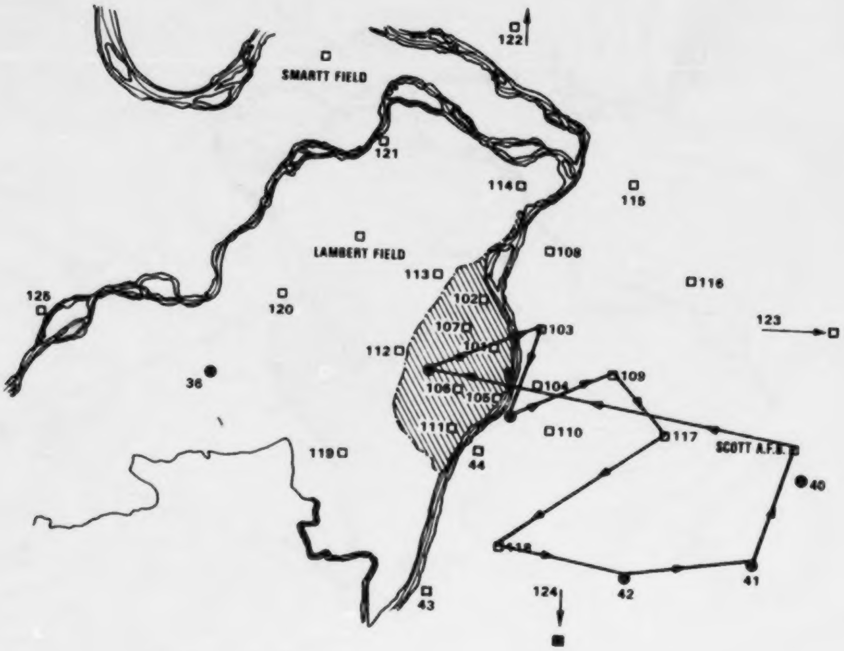
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Figure D-11. RAMS Network - Northwest-Southeast B

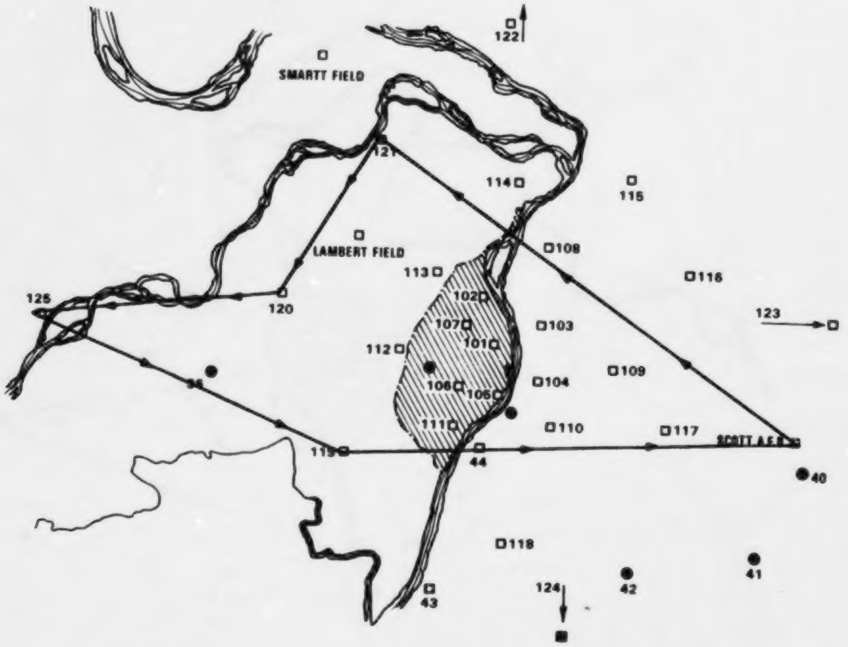
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Figure D-12. RAMS Network - East-West A

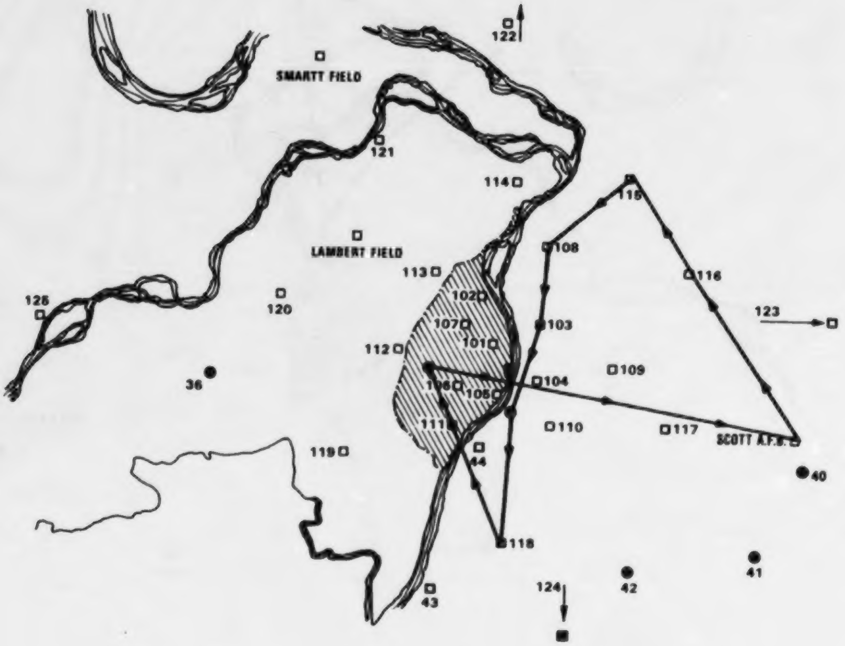
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Figure D-13. RAMS Network - East-West B

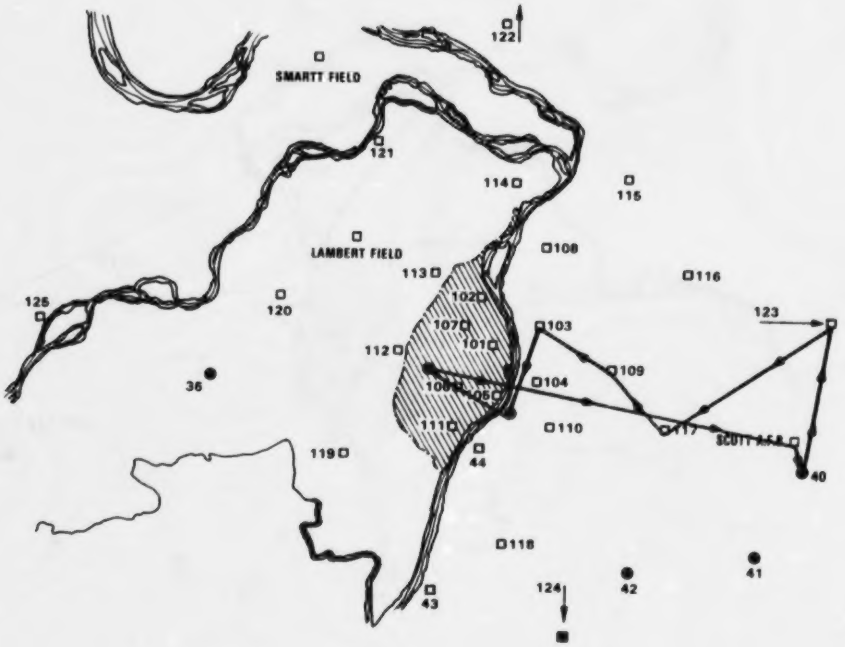
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Figure D-14. RAMS Network - East-West C

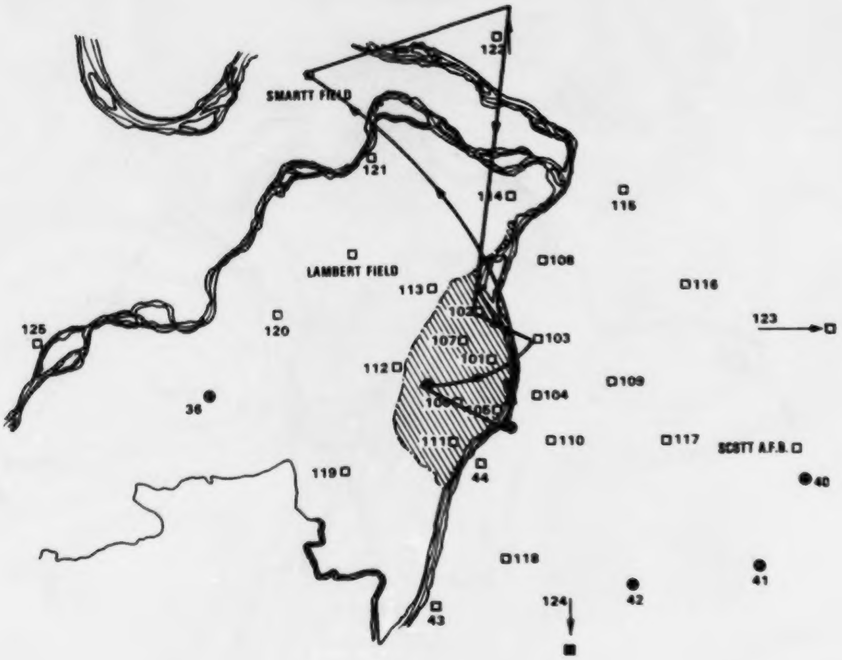

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Figure D-15. RAMS Network - North-South Pattern

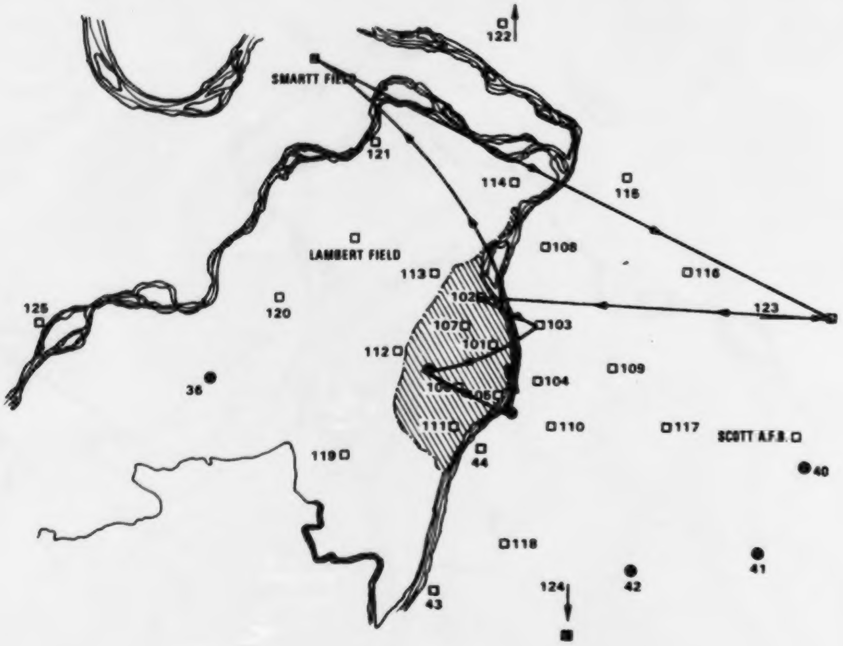

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Figure D-16. RAMS Network - East-West Pattern

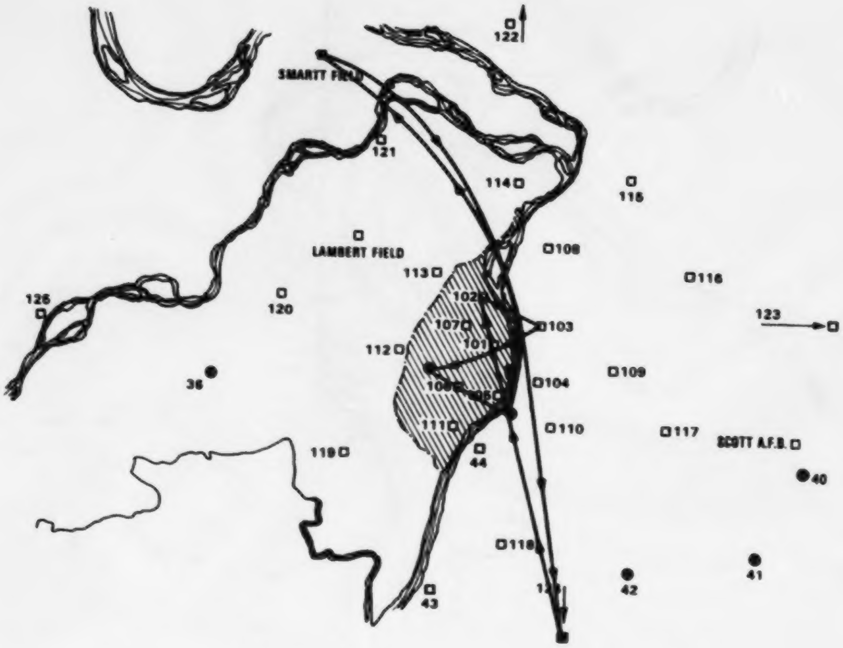
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Figure D-17. RAMS Network - South-North Pattern

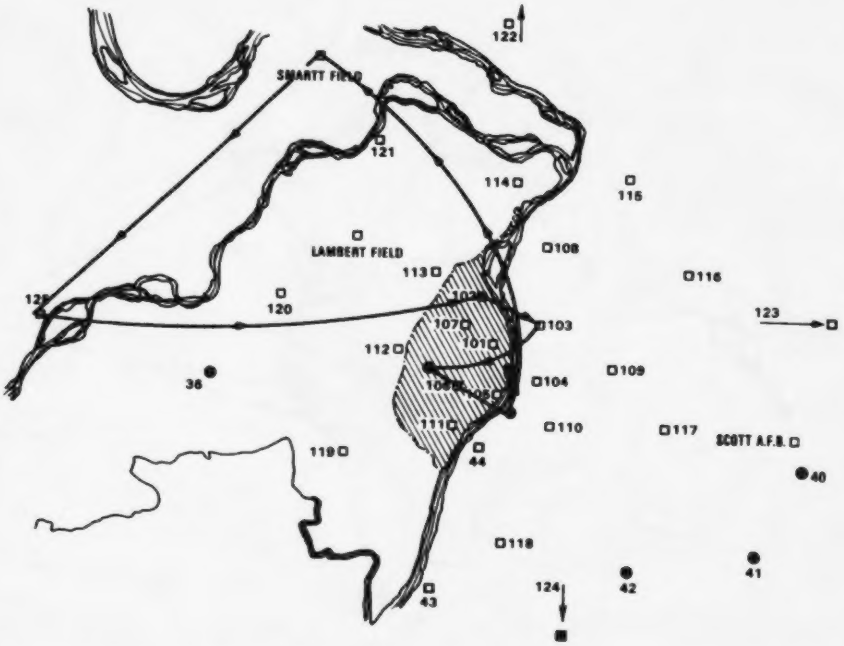
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Figure D-18. RAMS Network - West-East Pattern

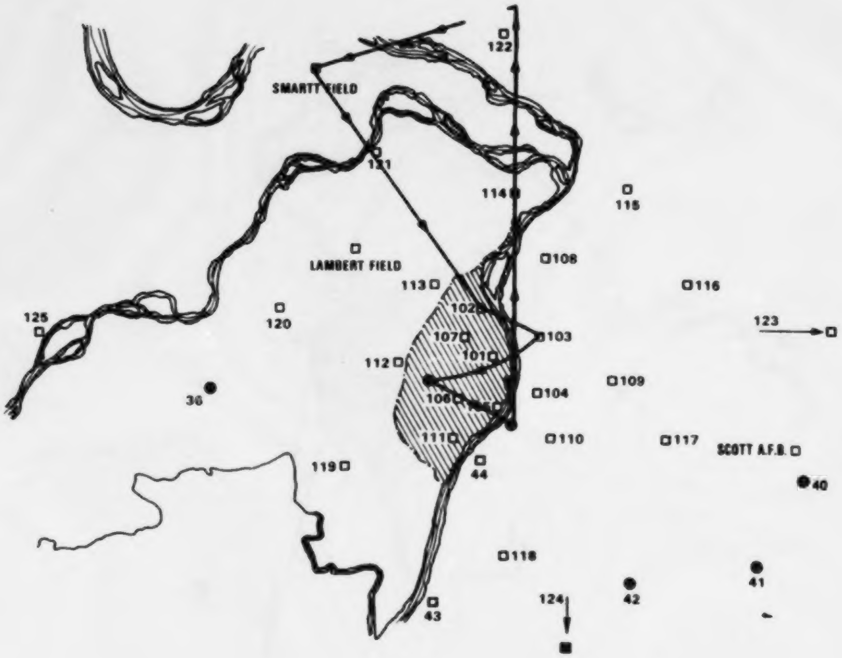
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Figure D-19. RAMS Network - North-South Final

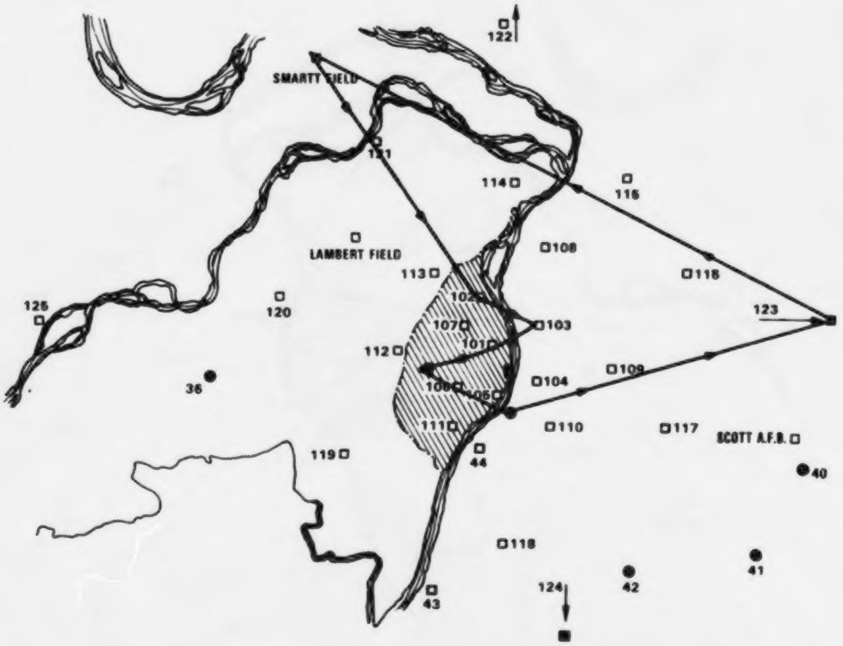
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Figure D-20. RAMS Network - East-West Final

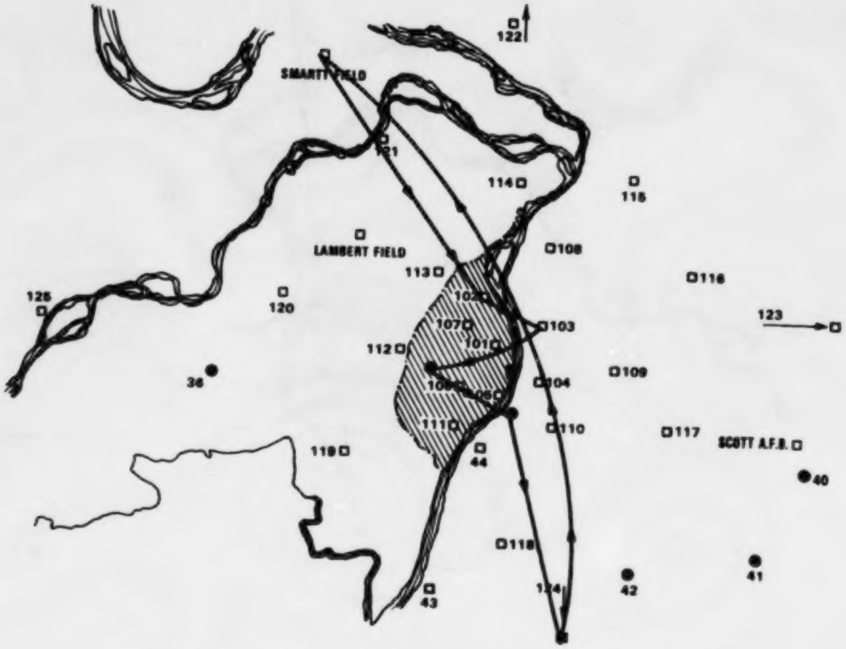
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Figure D-21. RAMS Network - South-North Final

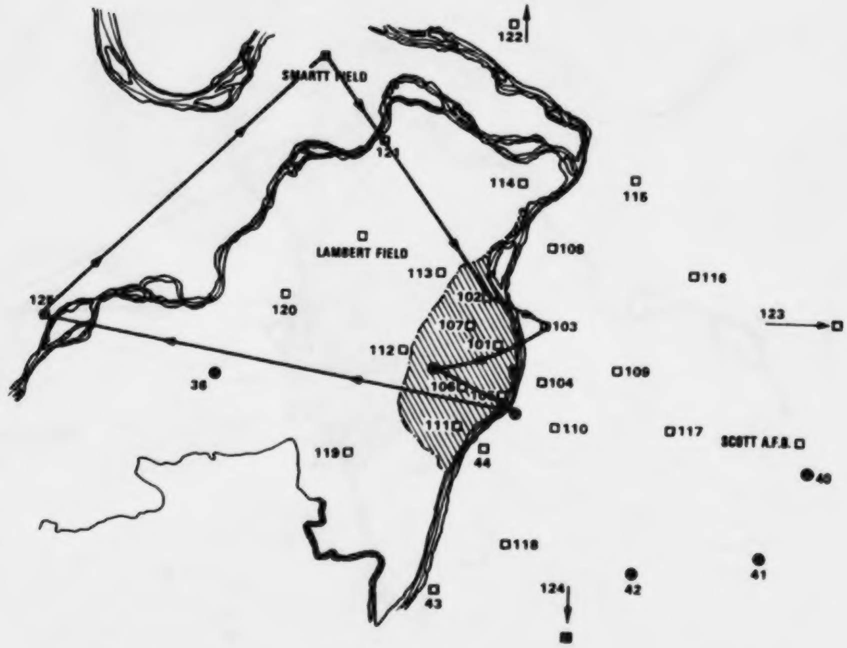
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Figure D-22. RAMS Network - West-East Final

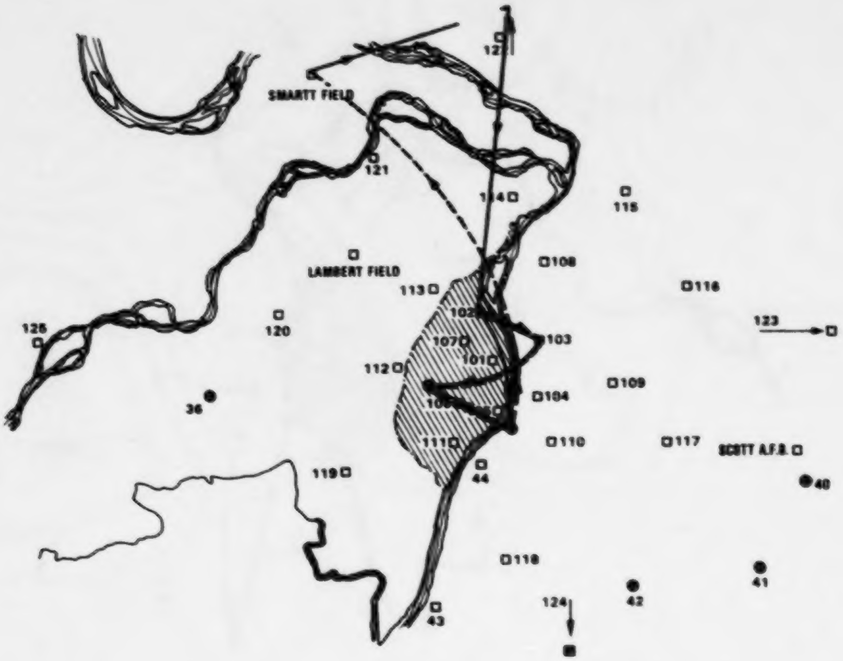
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Figure D-23. RAMS Network - North-South Double

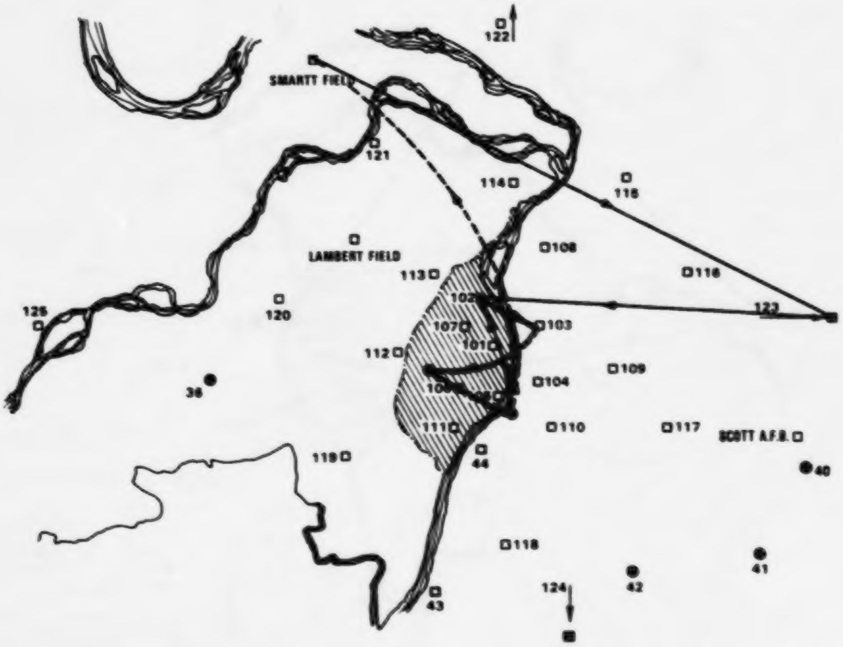
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Figure D-24. RAMS Network - East-West Double

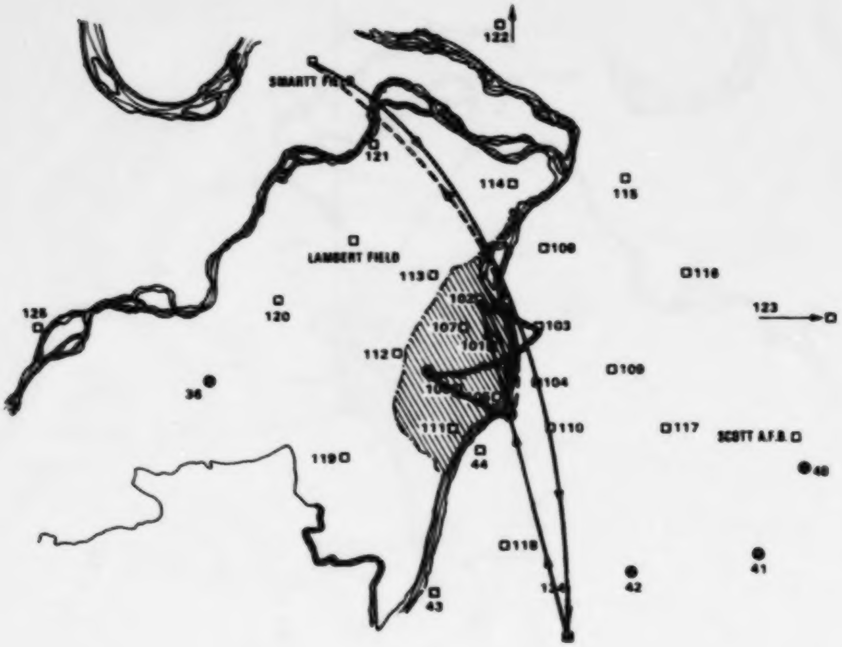
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Figure D-25. RAMS Network - South-North Double

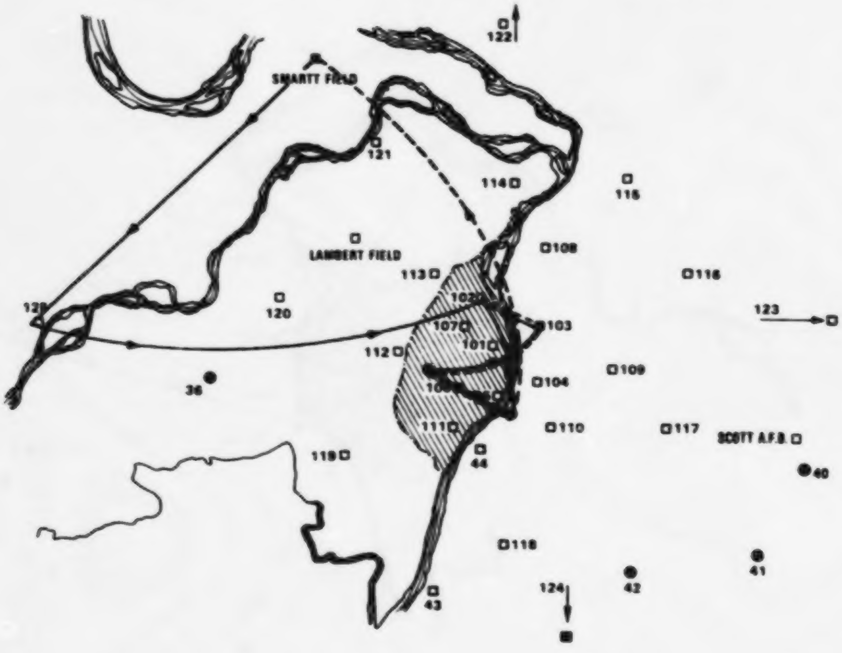
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Figure D-26. RAMS Network - West-East Double

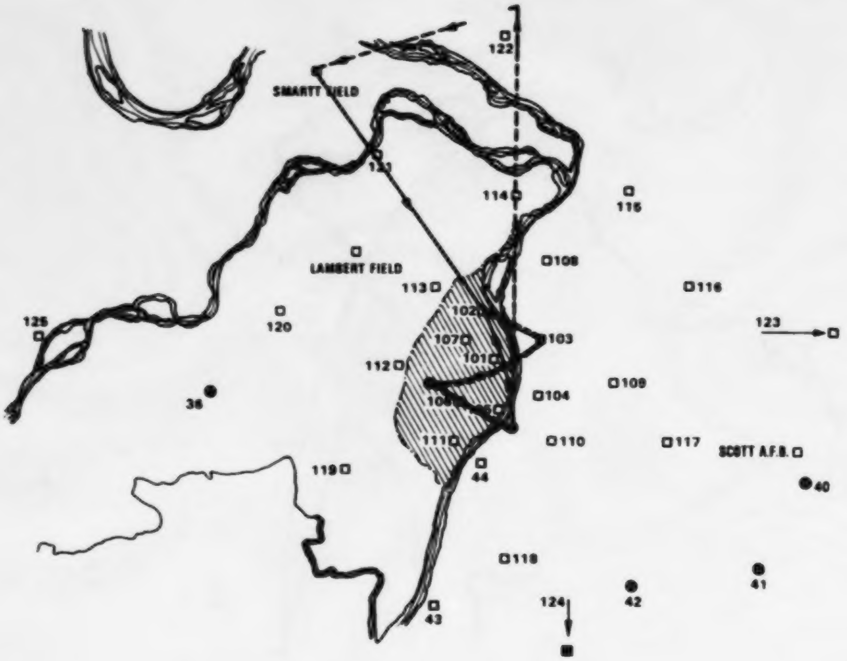
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Figure D-27. RAMS Network - North-South Double Final

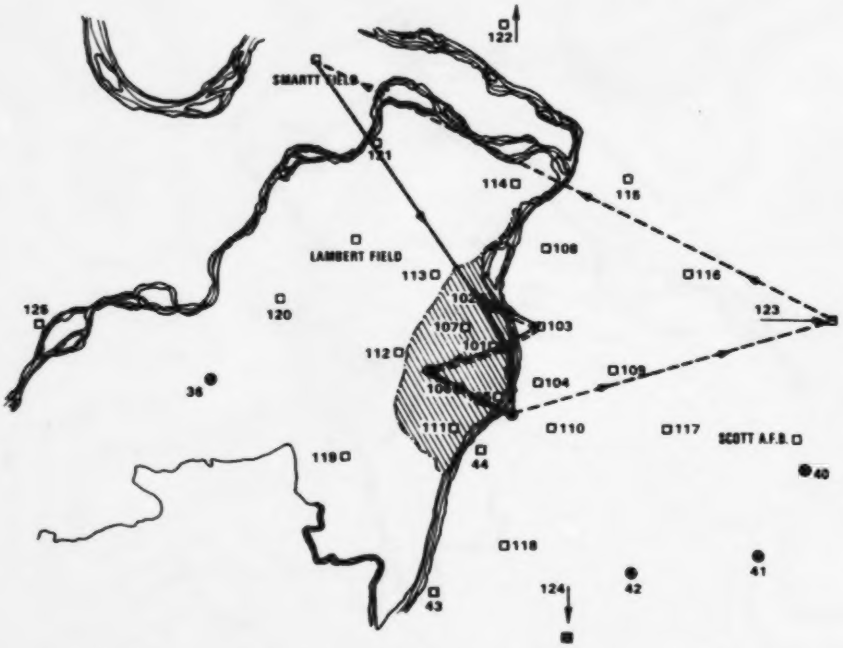
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Figure D-28. RAMS Network - East-West Double Final

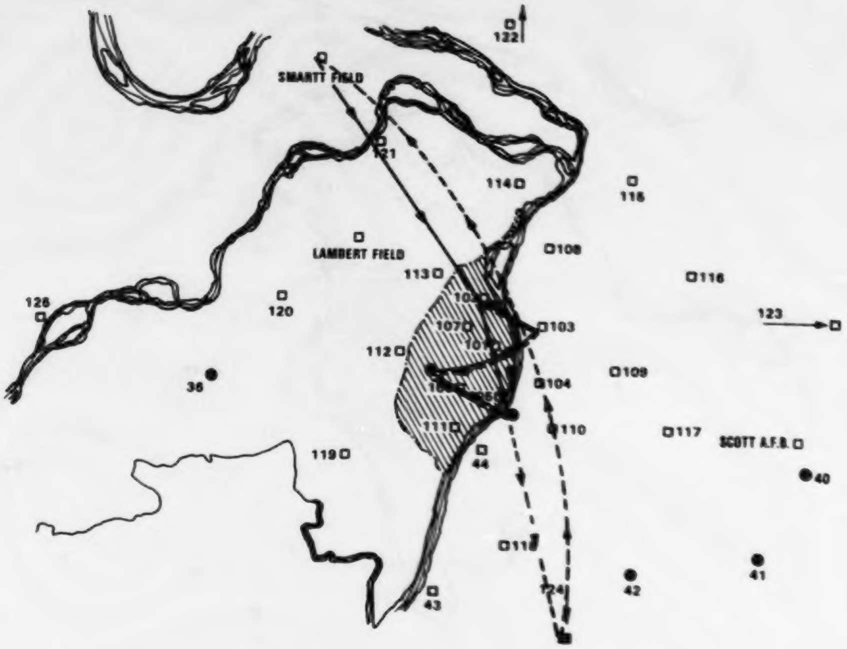
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Figure D-29. RAMS Network - South-North Double Final

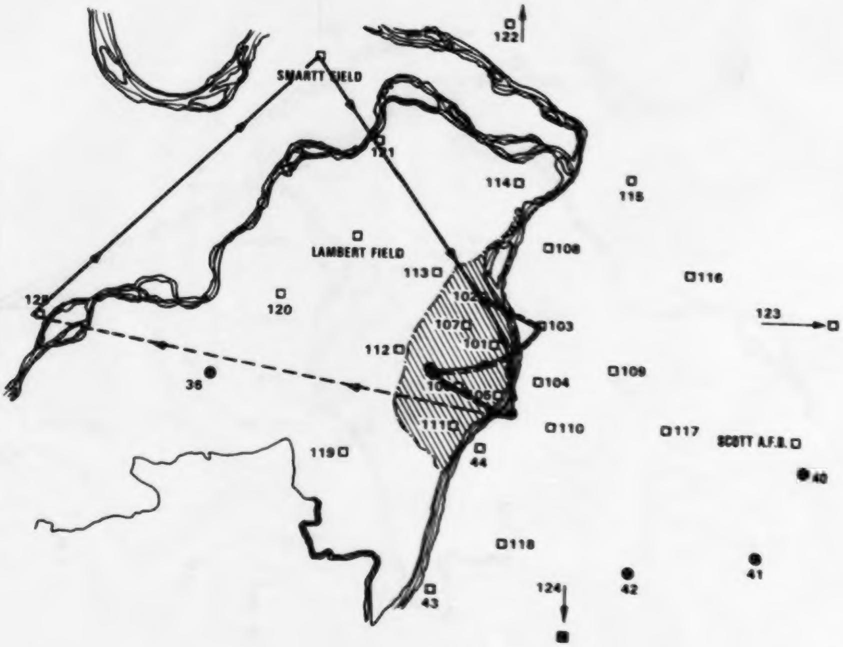
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Figure D-30. RAMS Network - West-East Double Final

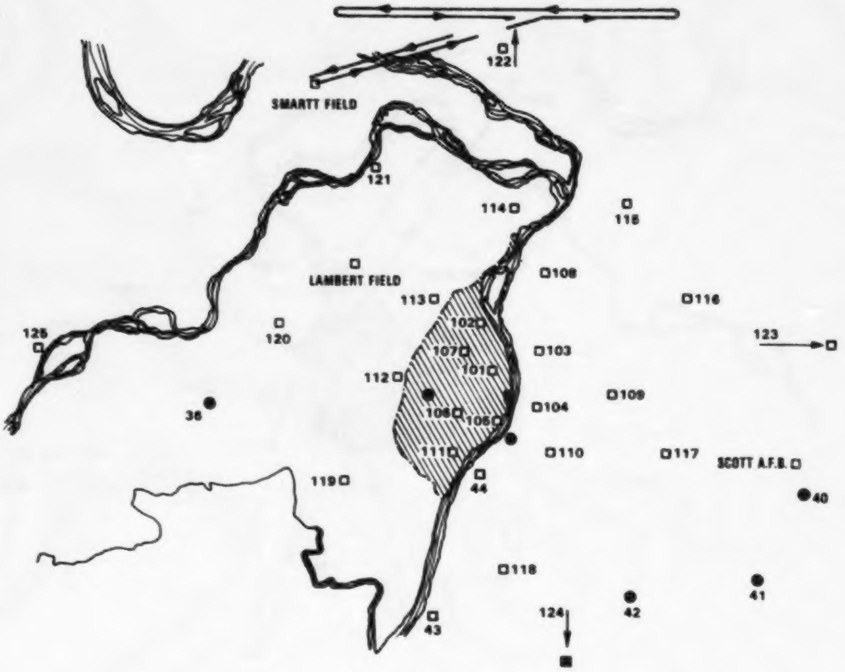
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Figure D-31. RAMS Network - North-Upwind (Crosswind) Pattern

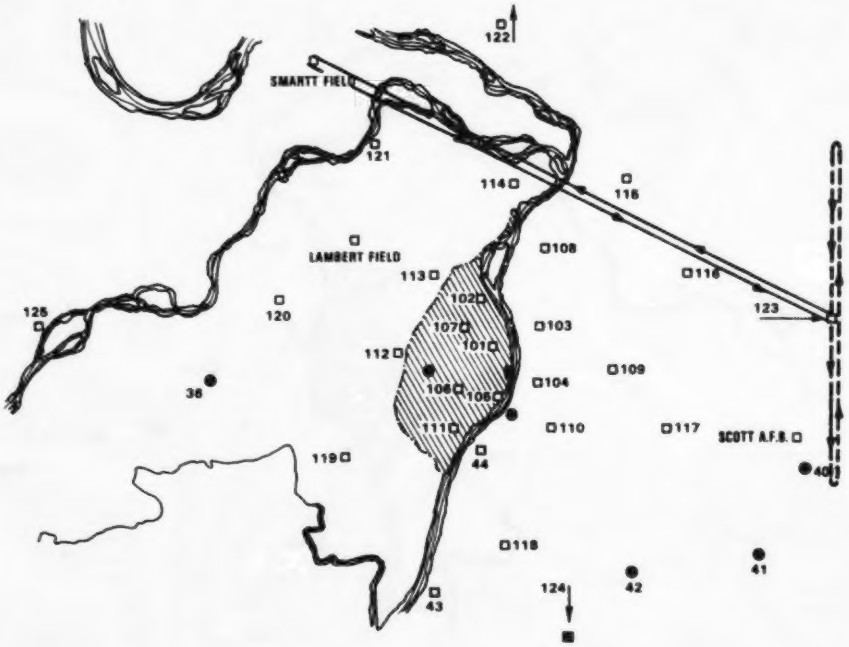
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Figure D-32. RAMS Network - East-Upwind (Crosswind) Pattern

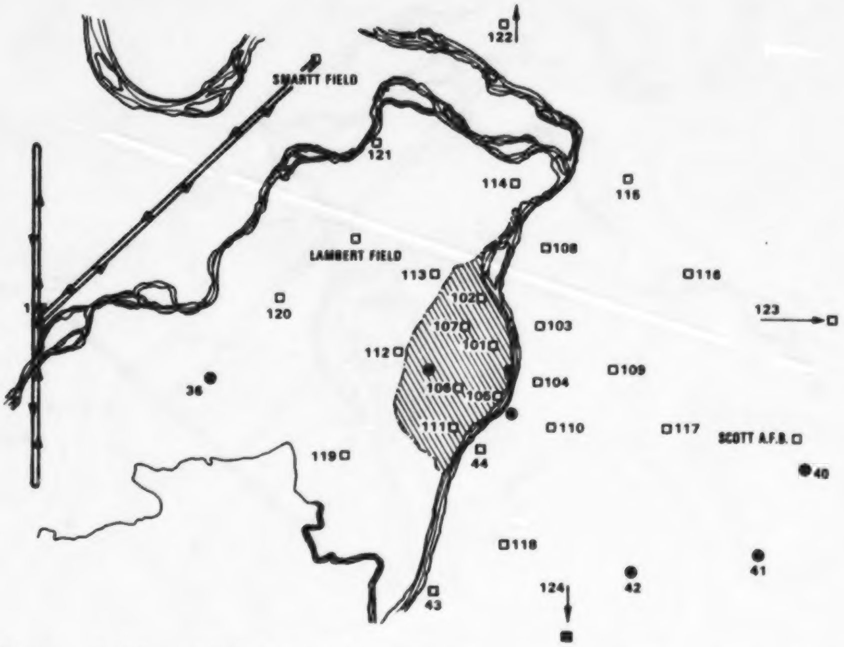
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Figure D-33. RAMS Network - West-Upwind (Crosswind) Pattern

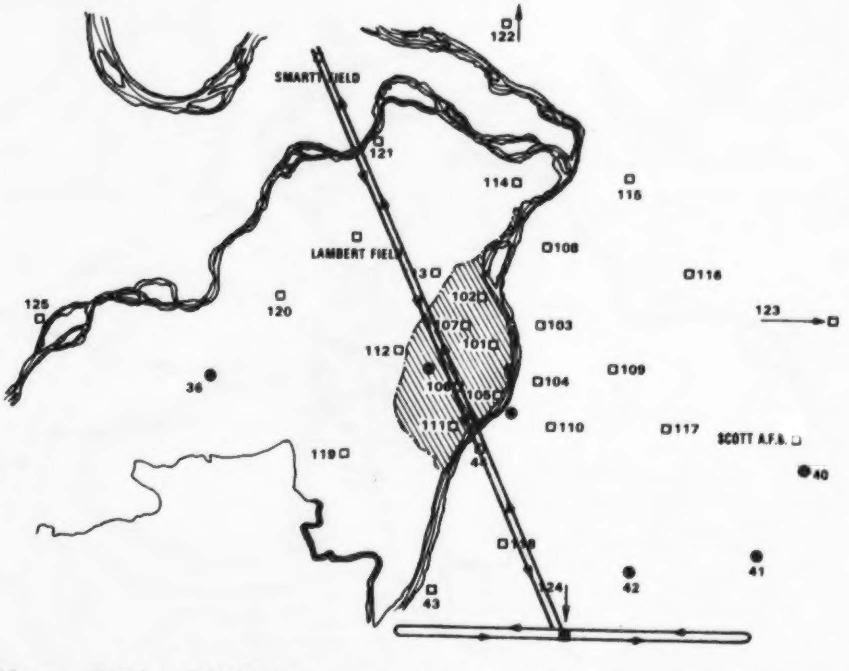
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Figure D-34. RAMS Network - South-Upwind (Crosswind) Pattern

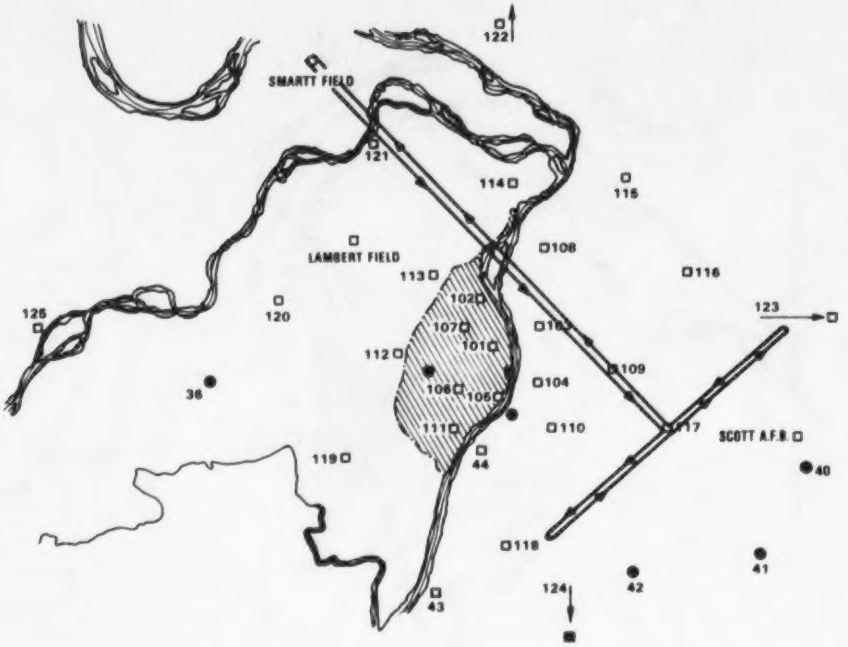
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Figure D-35. RAMS Network - Southeast-Upwind (Crosswind) Pattern

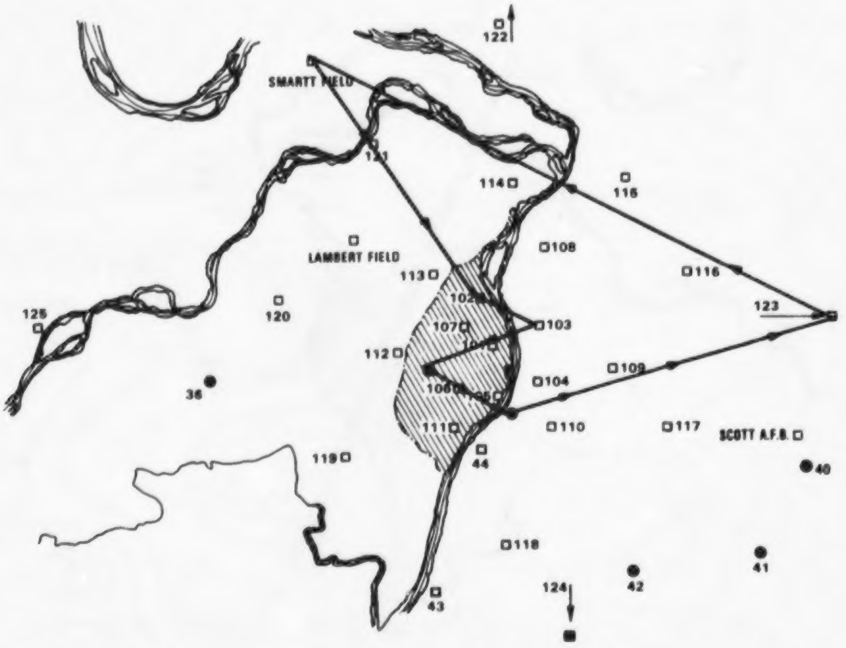
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Figure D-36. RAMS Network - West Downwind Final Pattern

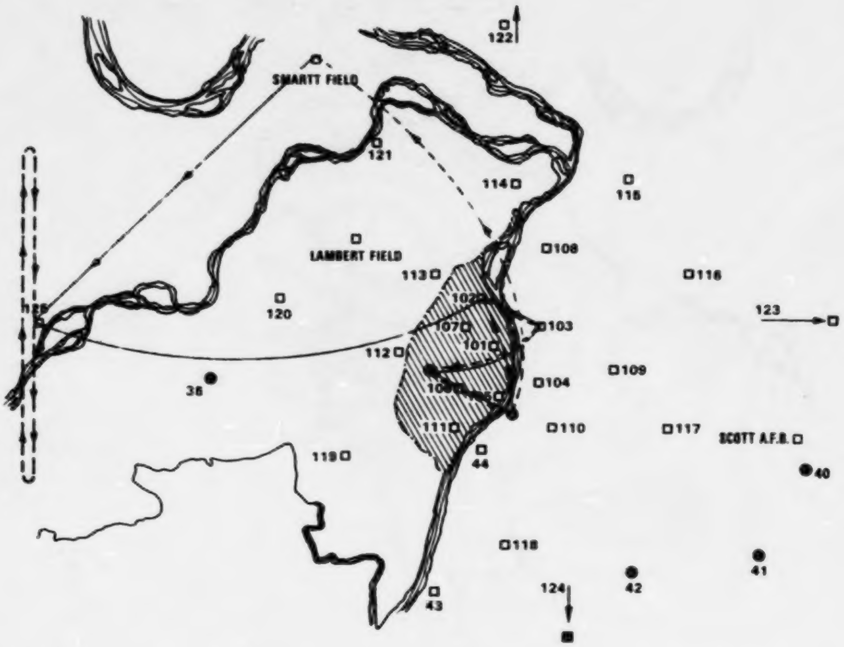
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Figure D-37. RAMS Network - West-East Double Background

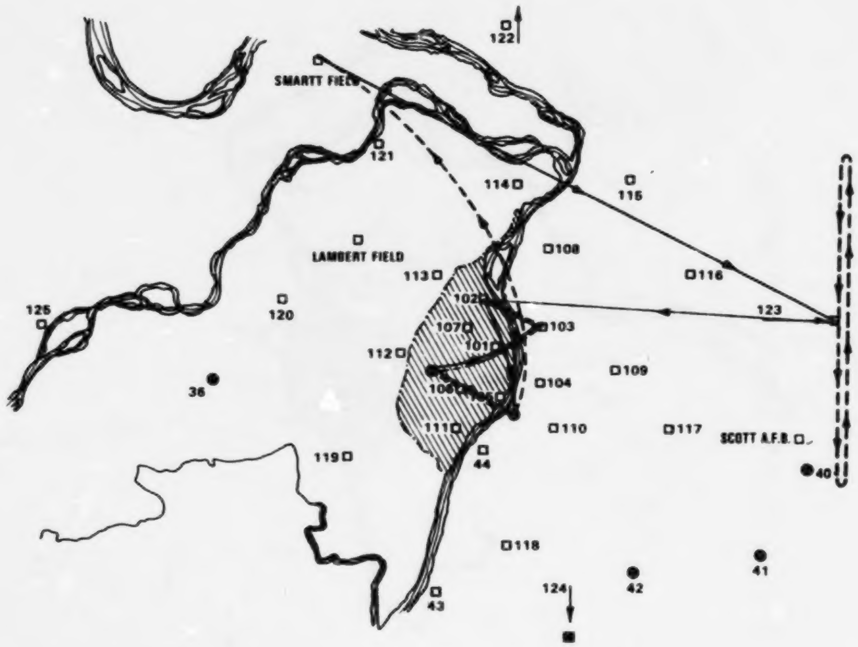
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Figure D-38. RAMS Network - East-West Double Background

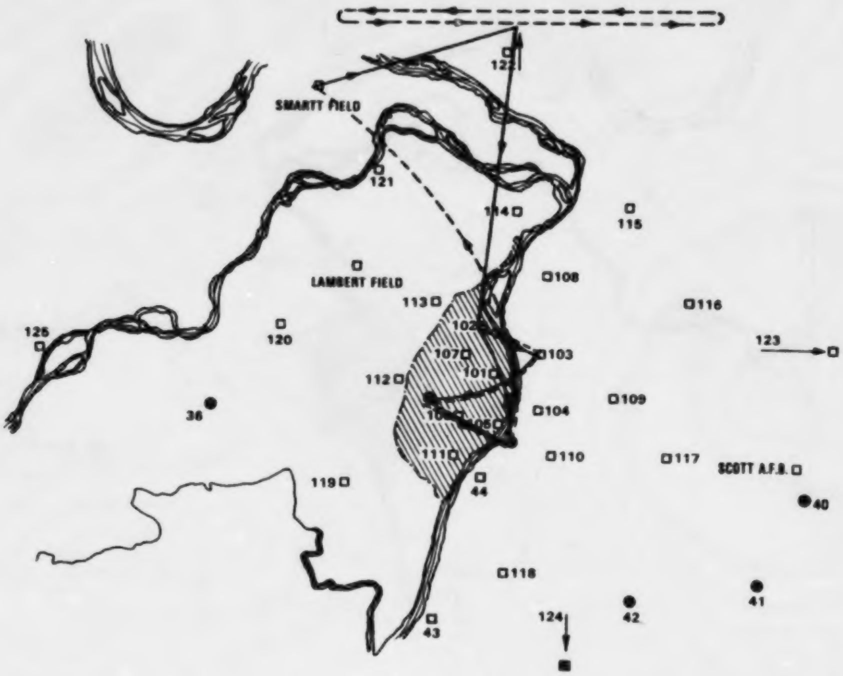
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Figure D-39. RAMS Network - North-South Double Background

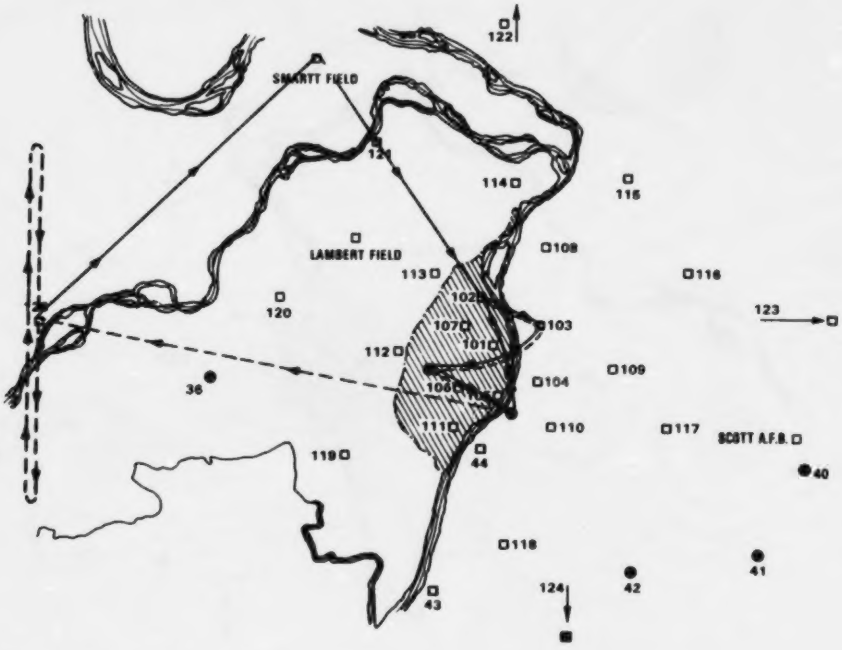
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Figure D-40. RAMS Network - West-East Double Final Background

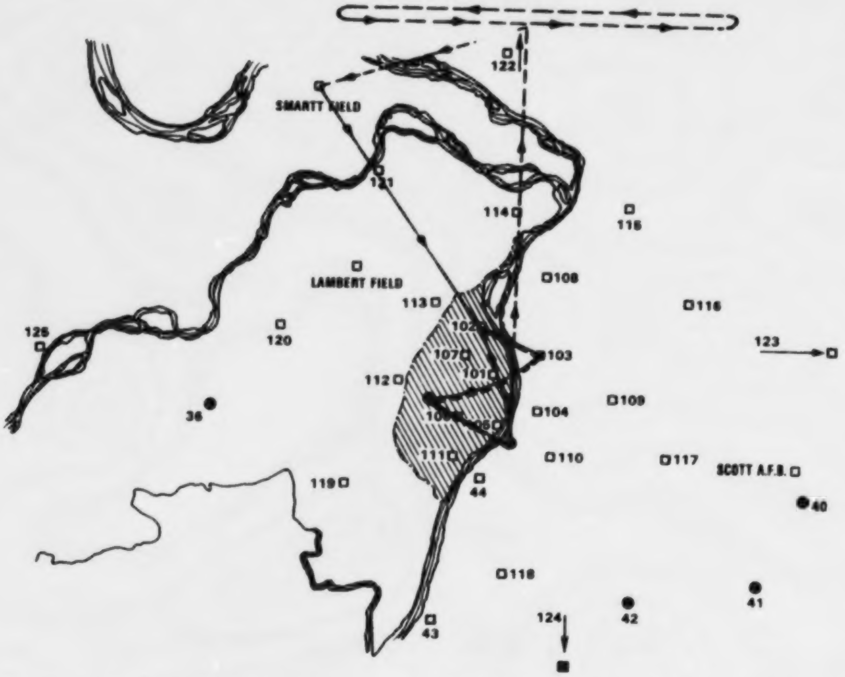
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Figure D-41. RAMS Network - East-West Double Final Background

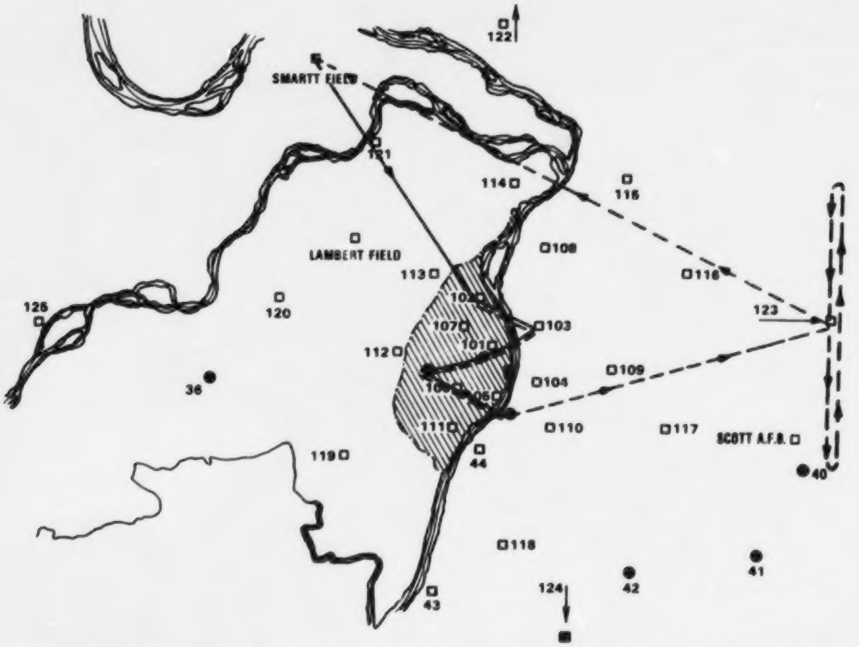
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Figure D-42. RAMS Network - North-South Double Final Background

APPENDIX E

DESCRIPTION OF SPECIAL EXPERIMENTS FOR RAPS PRINCIPAL INVESTIGATORS

TABLE E-1. DESCRIPTION OF SPECIAL EXPERIMENTS FOR RAPS PRINCIPAL INVESTIGATORS

Calendar and Julian Date		Data Tape Available	
		Yes	No
8/15/74	A flight was made in a square pattern at constant altitude around the Wood River, Illinois, and Alton, Illinois, refinery complex to assess the emissions; particular emphasis was placed on examination of hydrocarbon concentrations.	X	
4227	Principal Investigator - Mr. Stan Kopczynski, EPA.		
8/16/74	Flights were made in square patterns at constant altitude around four point sources in the St. Louis Metropolitan area. The point sources were the Chrysler assembly plant, General Motors assembly plant, American Can Co., and Monsanto Chemicals (E. St. Louis).	X	
4228	Principal Investigator - Mr. Stan Kopczynski, EPA.		
8/20/74	Cross patterns were flown over RAMS site 103 in coordination with ground monitoring units to determine the 3-dimensional distribution of ozone around the monitoring site.	X	
4232	Principal Investigator - Mr. Lou Chaney, Univ. of Michigan.		
12/4/74	Vertical profiles and horizontal cross sections were made of the Baldwin, Illinois, power plant plume at intervals downwind of the stacks to characterize the emissions.	X	
4338	Principal Investigator - Dr. Rudolph Husar, Washington University, St. Louis.		
2/19/75	Vertical profiles and horizontal cross sections were made of the Baldwin, Illinois, power plant plume at intervals downwind of the stacks to characterize the emissions.	X	
5050	Principal Investigator - Dr. Rudolph Husar, Washington University, St. Louis.		

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available Yes	No
2/27/75 5058	Plume study same as February 19, 1975 (Morning Flight).	X	
2/27/75 5058	Plume study same as February 19, 1975 (Afternoon Flight).	X	
3/1/75 5060	Plume study same as February 19, 1975 (Morning Flight)	X	
3/1/75 5060	Plume study same as February 19, 1975 (Afternoon Flight)	X	
3/3/75 5062	Plume study same as December 4, 1975.	X	
7/15/75 5196	Cross sections and vertical profiles were made of the St. Louis urban plume to determine the position of maximum O_3 concentrations and to characterize the pollutant transport downwind of the city. Principal Investigator - Mr. E.L. Martinez, EPA.	X	
7/18/75 5199	Same as July 15, 1975, O_3 study of the urban plume.	X	
7/23/75 5204	Bag samples of air were taken at various altitudes over RAMS sites 103 and 108 for hydrocarbon analysis. Principal Investigator - Mr. Stan Kopczynski, EPA.		X
7/24/75 5205	Bag samples of air were taken at various altitudes over RAMS site 108 for hydrocarbon analysis. Principal Investigator - Mr. Stan Kopczynski, EPA.	X	

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available	
		Yes	No
7/24/75 5205	Flight patterns were flown along freeways, near power plants, and over "clean" rural areas to collect particulate filter samples which were to be analyzed by electron microscopy. Principal Investigator - Mr. Ron Draftz, Illinois Institute of Technology.		X
7/25/75 5206	Same as July 15, 1975 O_3 study of the urban plume.	X	
7/30/75 5211	An experiment was run to examine sulfur transformations in the St. Louis area. Particulate filters and glass canister packed with an absorbant were used for the study. Air was drawn through the filters and the absorbant and the filters at locations upwind of the city, in the city center, and downwind of the city. Principal Investigator - Dr. William Wilson, EPA.	X	
8/3/75 5215	Same as July 15, 1975, O_3 study of the urban plume.	X	
8/4/75 5216	Same as February 19, 1975, plume study (Morning).	X	
8/4/75 5216	Same as February 19, 1975, plume study (Afternoon).		X
8/4/75 5216	Repetitive spirals from 4500 feet MSL down to 200 feet AGL at RAMS site 103 were done to determine the particulate-size distribution with the Royco 220 analyzer. The Royco system malfunctioned.		X

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available Yes	No
8/4/75 5216	Metal cans were pumped full of air for subsequent laboratory analysis for fluorocarbons. One sample was taken upwind of the city and five samples were taken across the urban plume downwind of the city. Principal Investigator - Dr. Jack Durham, EPA.		X
8/5/75 5217	Same as February 19, 1975, plume study (Morning).	X	
8/5/75 5217	Same as February 19, 1975, plume study (Afternoon).	X	
8/5/75 5217	Same as August 4, 1975, study with cans for fluorocarbon analysis.		X
8/5/75 5217	Same as July 30, 1975, study of sulfur transformations.		X
8/6/75 5218	Same as July 15, 1975, O_3 study in the urban plume.	X	
8/7/75 5219	Helicopter spirals were made over RAMS sites 122, 114, 118, and 103 from 4,000 feet MSL to 1,000 feet MSL to determine particulate-size distribution with a Royco 220 and supporting equipment. Principal Investigator - Dr. Jim Peterson, EPA.		X
8/7/75 5219	Bag samples for hydrocarbon analysis were taken upwind and downwind of the Wood River refinery complex. Principal Investigator - Mr. Stan Kopczynski, EPA.		X

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available	
		Yes	No
8/7/75 5219	Bag samples for CO analysis were taken at various altitudes above RAMS site 108. Data correlated with ground monitors to determine the 3-dimensional distribution of CO. Principal Investigator - Mr. Lou Chaney, Univ. of Michigan.		X
8/8/75 5220	Same as July 30, 1975, study of sulfur transformation.		X
8/8/75 5220	Bag samples were taken to determine the changes in hydrocarbon composition across the city. Samples were taken upwind, near the center, and downwind of the city. Principal Investigator - Mr. Stan Kopczynski, EPA.		X
8/8/75 5220	Multi-stage high volume samples of air were collected for subsequent chemical analysis. High volume samples were collected upwind of the city and at several locations over the downtown area. Principal Investigator - Dr. William Wilson, EPA.		X
8/8/75 5220	Sulfur hexafluoride was released from towers to simulate stack emissions. The helicopters collected air samples in syringes along cross sections of the extended plume path at several intervals to determine plume dispersion characteristics. Principal Investigator - Dr. Fred Shair, California Institute of Technology.		X
8/9/75 5221	Same as August 8, 1975, sulfur hexafluoride release.		X
8/11/75 5223	Same as August 8, 1975, sulfur hexafluoride release.		X

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available Yes	No
8/11/75 5223	Same as July 18, 1975, NO study of urban plume.		X
8/12/75 5224	Bag samples were taken upwind and downwind of the Wood River refinery complex for hydrocarbon analysis.		X
8/12/75 5224	Same as August 8, 1975, bag study across the city.		X
8/12/75 5224	Same as August 7, 1975, study of CO distribution.		X
8/13/75 5225	Orbits were made at 4,000, 3,000, 2,000 and 1,000 feet over RAMS site 118 to determine particulate-size distribution with the Royco 220 and supporting equipment.		X
8/15/75 5227	Same as August 8, 1975, sulfur hexafluoride plume study.		X
8/15/75 5227	Same as August 8, 1975, hydrocarbon bag sampling experiment.		X
2/22/76 6053	Vertical spirals were made over a number of RAMS ground stations and over the RAMS pibal stations. The emphasis was on collecting temperature soundings. The vertical profiles were, to the extent possible, taken at the same time as radio-sondes were launched. Principal Investigator - Dr. Jason Ching, EPA.	X	

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available	
		Yes	No
2/23/76 6054	Same as February 22, 1976, temperature profile studies (Morning).	X	
2/23/76 6054	Same as February 22, 1976, temperature profile study (Afternoon).	X	
2/24/76 6055	Same as February 22, 1976, study of temperature profiles.	X	
2/25/76 6056	Vertical profiles were made over RAMS sites 118 and 103 to determine the size distribution of particulate matter with the Royco 220 and supporting equipment. Principal Investigator - Dr. Jim Peterson, EPA.		X
3/6/76 6066	Vertical profiles were made over Smartt Field and other selected sites to obtain temperature profiles. Seven missions were flown on this date. Principal Investigator - Dr. James McElroy, EPA.	X	
3/7/76 6067	Same as March 6, 1976, temperature profiles. Three missions were flown on this date.	X	
7/16/76 6198	Same as February 25, 1976, Royco mission.		X
7/20/76 6202	Same as February 25, 1976, Royco mission.		X

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available Yes	No
7/20/76 6202	Same as July 15, 1975, O_3 study of urban plume.		X
7/22/76	Same as July 15, 1975, O_3 study of urban plume.	X	
7/23/76 6205	Cross sections and vertical profiles were made of the St. Louis urban plume in support of the DaVinci balloon flights. Three flights were made on this date. Principal Investigator - Dr. Bernie Zak, Sandia.	X	
7/23/76 6205	Same as February 25, 1976, Royco mission.	X	
7/23/76 6205	Same as July 15, 1975, O_3 study of urban plume.		X
7/26/76 6208	Same as February 25, 1976, Royco mission.	X	
7/27/76 6209	Same as March 6, 1976, temperature studies.		X
7/28/76 6210	Vertical profiles were made over RAMS sites 122 and 114 do determine the size distribution of particulate matter with the Royco 220 and support equipment. Principal Investigator: Dr. Jim Peterson, EPA.		X

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available	
		Yes	No
7/29/76 6211	Vertical profiles were made over Sangamon, Illinois, to provide information on the temperature structure of the atmosphere. The work was done to support studies done by Argonne National Laboratories. Principal Investigator - Dr. Bruce Hicks, Argonne National Laboratory.	X	
7/30/76 6212	Same as March 6, 1976, temperature studies.	X	
7/30/76 6212	Same as February 22, 1976, temperature studies.	X	
7/31/76 6213	Study of plume behavior, Portage-Des-Sioux Power Plant.		X
8/1/76 6214	Same as February 22, 1976, temperature studies.	X	
8/2/76 6215	Same as March 6, 1976, temperature profile study.	X	
8/2/76 6215	Same as February 25, 1976, Royco mission.		X
8/3/76 6216	Same as March 6, 1976, temperature profile study.	X	
8/4/76 6217	Same as March 6, 1976, temperature profile study.	X	

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available	
		Yes	No
8/8/76 6221	Same as March 6, 1976, temperature profile study (Early morning).	X	
8/8/76 6221	Same as July 31, 1976, study of Portage-Des-Sioux plume (Mid-morning).	X	
8/10/76 6223	A downward-looking radiometer was carried by the helicopter to measure the reflected light intensity	X	
8/10/76 6223	Same as July 15, 1975, O_3 study of urban plume.		X
8/12/76 6225	Same as July 31, 1976, study of Portage-Des-Sioux plume. Four flights were made on this date.	X	
11/8/76 6313	Horizontal cross sections and vertical profiles of the Labadie power plant plume were made to gather pollution data for coordination with data being collected by the California Institute of Technology on sulfur hexafluoride dispersion. The sulfur hexafluoride was released concurrent with helicopter measurements, and data on sulfur hexafluoride concentrations were collected both on the ground and in the air by Cal. Tech. researchers. Principal Investigator - Dr. Fred Shair, California Institute of Technology.	X	
11/9/76 6314	Same as November 8, 1976, sulfur hexafluoride study.	X	

(Continued)

TABLE E-1. (Continued)

Calendar and Julian Date		Data Tape Available	
		Yes	No
11/12/76 6317	Same as November 8, 1976, sulfur hexafluoride study.	X	

APPENDIX F

SUMMARY REPORT OF HELICOPTER DATA

This brief summary of measurements is provided as a preview of the data in each flight. It proceeds in chronological order and includes data flights within the following periods: 22574 - 23974 (Julian Day 225, 1974 to Day 239, 1974), 31674 - 34074, 03475 - 06475, 19475 - 22475, 04576 - 07276, 19876 - 22676 and 30076 - 32376. Flight times are based on the first to last records with thumbwheel N1 set to 1 or 4, except for flights 80, 81 and 110 which are based on N1=2. Flight numbers correspond to the sequential files archived in the Regional Air Pollution Study data bank at the EPA National Computer Center. A complete copy of the data is available from the National Technical Information Service. For further information on the data and the NTIS accession number contact:

Chief, Data Management and Analysis Section
ESRL MD AMAB (MD-80)
Environmental Protection Agency
Research Triangle Park, NC 27711

Appendix D contains descriptions of the RAMS support missions. The list of sites flown over is derived from the N5 and N6 thumbwheel settings. These correspond to the last two digits of the RAMS station number (Table D-1). Other sites are identified in Table D2. The order presented is in the sequence contained within the flight data record. It may not be a complete list for any given flight and a note, "SEE FLIGHT DESCRIPTION", was inserted for each flight with no sites indicated. Appendix E provides information on the special missions.

The maxima and minima presented in the summary are in the units originally recorded. Users of these data are cautioned to apply their own editing standards to the data. Editing codes appearing in this summary are not in the basic data record. The notation, **, is substituted for values generated from excessive instrument noise, or relational inconsistency. Some of this noise was probably due to RFI from radio communications, other to instrument instability. A BMDL (below minimum detectable limit) is substituted for gas or b_{scat} minima less than zero. No valid O_3 maximum above 0.30 ppm was seen in summer flights nor above 0.10 ppm in winter flights. None of the CO data above 10.0 ppm appear to be valid. An upper limit of 30.0 m^{-1} applies to b_{scat}. OAT (outside ambient temperature) and DPT (dew point temperature) are quite noisy. These data were limited to a range of -30.0°C to +50.0°C further, DPT must be less than OAT. Additional editing was also done based upon examination of some flight records. In several instances the NO values exceed the NO_x values; however, this is due to the different response characteristics of the measurement systems. The OAT and DPT data in flights 27 - 33 are erratic and *** was substituted for them. Also in flights 214 - 225 the NO and NO_x do not have mutually supporting patterns so a substitution of *** was made in several cases. Finally, blanks indicate no valid measurements are available.

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                        SUMMARY REPORT OF HELICOPTER DATA
                (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 225  YEAR = 1974  TUE, AUG 13  TIMES: 06:35:10 - 10:42:20  FLIGHT NO. =   1
SITES FLOWN OVER:     18   5   6   3  13  21   8  15  23
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .001     .002     BMDL     BMDL      BMDL     20.3      **       .2
MAXIMA:        .101     .338     .282     .765       3.4     24.1     23.2     2.5      2620. FT.

JULIAN DAY = 226  YEAR = 1974  WED, AUG 14  TIMES: 09:00:52 - 11:44:18  FLIGHT NO. =   2
SITES FLOWN OVER:     18   2  16   3  13  21   8  15  23
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .007     BMDL     BMDL     .001      BMDL      **               .4
MAXIMA:        .122     .166     .397     .356       8.2      **              6.7      3251. FT.

JULIAN DAY = 226  YEAR = 1974  WED, AUG 14  TIMES: 14:28:12 - 16:49:32  FLIGHT NO. =   3
SITES FLOWN OVER:     18   5   6   3  13  21   8  15  23
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .042     BMDL     .022     BMDL      BMDL      **               .8
MAXIMA:        .100     .093     .449     .142       5.0      **              5.6      5093. FT.

JULIAN DAY = 227  YEAR = 1974  THU, AUG 15  TIMES: 08:22:11 - 09:49:16  FLIGHT NO. =   4
SITES FLOWN OVER:     40
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .015     BMDL     .028     BMDL      BMDL      **               .9
MAXIMA:        .073     .066     .166     .487       5.2      **             12.1      1661. FT.

JULIAN DAY = 227  YEAR = 1974  THU, AUG 15  TIMES: 11:17:00 - 13:44:05  FLIGHT NO. =   5
SITES FLOWN OVER:     18   5   6   3  13  21   8  15  23
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .016     .006     .025     BMDL      BMDL     16.3               .6
MAXIMA:        .146     .115     .226     .111       **      27.4              2.7      3198. FT.

JULIAN DAY = 228  YEAR = 1974  FRI, AUG 16  TIMES: 08:23:52 - 10:02:55  FLIGHT NO. =   6
SITES FLOWN OVER:     80  60  10  90  70
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        BMDL     .007     .005     BMDL      BMDL     20.3      **
MAXIMA:        .072    1.130    1.300     .251       **      28.6     28.5              1820. FT.

JULIAN DAY = 228  YEAR = 1974  FRI, AUG 16  TIMES: 11:03:58 - 13:05:58  FLIGHT NO. =   7
SITES FLOWN OVER:     25   5   3  23
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        BMDL     BMDL     BMDL     BMDL      BMDL      **       **
MAXIMA:        .062    1.470    1.380    1.820       **       **       **               3121. FT.

JULIAN DAY = 231  YEAR = 1974  MON, AUG 19  TIMES: 06:53:16 - 08:12:31  FLIGHT NO. =   8
SITES FLOWN OVER:     17  18   6   2   3
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:                 BMDL     BMDL     .000               21.7     18.8     1.0
MAXIMA:                 .604     .707    1.180               25.6     21.8    16.0      1778. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)
JULIAN DAY = 231  YEAR = 1974  MON, AUG 19  TIMES: 09:31:20 - 10:38:00  FLIGHT NO. =   9
SITES FLOWN OVER:      3   8  15  16
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .013    .002     .007     BMDL     BMDL      21.8     13.4       .7
MAXIMA:       .107    .019     .028     .079      2.4      25.9     22.4      6.8     1620. FT.

JULIAN DAY = 231  YEAR = 1974  MON, AUG 19  TIMES: 12:32:20 - 15:02:00  FLIGHT NO. =  10
SITES FLOWN OVER:     18    5    6    3   13   21    8  15  23
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               .003     .038     .005               26.0     14.3      1.6
MAXIMA:               .069     .209     .243               31.1     22.7     22.1     1864. FT.

JULIAN DAY = 231  YEAR = 1974  MON, AUG 19  TIMES: 14:17:28 - 16:04:38  FLIGHT NO. =  11
SITES FLOWN OVER:     17   18    6    2    3    8   15  16
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL    .012     .033     BMDL     BMDL      21.4       **      1.1
MAXIMA:       .160    .047     .106     .423      9.6      29.0     21.9      5.2     2101. FT.

JULIAN DAY = 232  YEAR = 1974  TUE, AUG 20  TIMES: 07:05:36 - 10:32:47  FLIGHT NO. =  12
SITES FLOWN OVER:     18    5    6    3   13   21    8  15  23
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .006    .009     .008     BMDL     BMDL      14.6       **       .1
MAXIMA:       .192    .386     .295    1.140       **      24.6     22.0      7.3     5995. FT.

JULIAN DAY = 232  YEAR = 1974  TUE, AUG 20  TIMES: 09:28:25 - 11:00:50  FLIGHT NO. =  13
SITES FLOWN OVER:      3    3    3
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               .050     .079     .001     BMDL      23.8     19.5      3.6
MAXIMA:               .083     .152     .104      5.5      28.6     23.3      8.4     1357. FT.

JULIAN DAY = 232  YEAR = 1974  TUE, AUG 20  TIMES: 14:19:20 - 15:27:08  FLIGHT NO. =  14
SITES FLOWN OVER:     38
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               .003     .012     .003     BMDL      27.5     15.8      2.4
MAXIMA:               .063     .084     .043      2.2      31.8     20.4      5.3     1586. FT.

JULIAN DAY = 233  YEAR = 1974  WED, AUG 21  TIMES: 06:26:40 - 07:23:50  FLIGHT NO. =  15
SITES FLOWN OVER:     17   18    2
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .003    BMDL     .011     .000     BMDL        **       **      1.2
MAXIMA:       .122    .079     .117     .270      2.6      23.2       **      3.7     3570. FT.

JULIAN DAY = 233  YEAR = 1974  WED, AUG 21  TIMES: 08:43:20 - 12:25:20  FLIGHT NO. =  16
SITES FLOWN OVER:     18    5    6    3   13   21    8  15  23
PARAMETERS:     03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               .005     BMDL     .000     BMDL      19.8       **       .2
MAXIMA:               .896     .987    1.990      6.5        **     22.5      6.7     4741. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 233  YEAR = 1974  WED, AUG 21  TIMES: 13:52:15 - 15:23:05  FLIGHT NO. =  17
SITES FLOWN OVER:     25
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:                 .006    .011     BMDL     BMDL     21.8     11.5      .8
MAXIMA:                 .030    .098     .190      3.6     31.2     20.6     3.2       4073. FT.

JULIAN DAY = 234  YEAR = 1974  THU, AUG 22  TIMES: 06:39:56 - 08:36:16  FLIGHT NO. =  18
SITES FLOWN OVER:     17  18   6   2   3   8  15  16
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL      .002    .030     .000     BMDL     21.1     15.0      .4
MAXIMA:       .087      .136    .255     .446       **     25.8     20.7    14.1       3565. FT.

JULIAN DAY = 234  YEAR = 1974  THU, AUG 22  TIMES: 07:10:00 - 09:07:30  FLIGHT NO. =  19
SITES FLOWN OVER:     18   5   6   3  13  21   8  15  23
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL      BMDL    BMDL     BMDL     BMDL     16.6       **      .1
MAXIMA:       .092      .238    .243     .654      2.4     23.7     21.3     6.4       2961. FT.

JULIAN DAY = 234  YEAR = 1974  THU, AUG 22  TIMES: 11:05:20 - 12:16:50  FLIGHT NO. =  20
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .019      .005    BMDL     .000       .9     22.5     15.8      .6
MAXIMA:       .092      .056    .088     .826      9.8     26.4     21.0    11.2       2373. FT.

JULIAN DAY = 234  YEAR = 1974  THU, AUG 22  TIMES: 11:05:30 - 12:17:00  FLIGHT NO. =  21
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .017      BMDL    BMDL     BMDL     BMDL     20.3       **      .3
MAXIMA:       .072      .035    .023     .570      1.5     23.8     22.4    14.8       2305. FT.

JULIAN DAY = 238  YEAR = 1974  MON, AUG 26  TIMES: 09:40:35 - 12:21:45  FLIGHT NO. =  22
SITES FLOWN OVER:     18   6   3  13  21  15  23  23
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:                 .023    BMDL     .000     BMDL     24.1     18.3      .2
MAXIMA:                1.300   1.410     .962       **     36.3     26.9     5.9       2203. FT.

JULIAN DAY = 238  YEAR = 1974  MON, AUG 26  TIMES: 15:10:00 - 16:46:05  FLIGHT NO. =  23
SITES FLOWN OVER:     25   5   3  23
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .021      BMDL    BMDL     BMDL     BMDL     21.4     15.6     2.8
MAXIMA:       .150      .451    .470    1.650      7.6     30.1     22.7    15.9       3209. FT.

JULIAN DAY = 238  YEAR = 1974  MON, AUG 26  TIMES: 15:31:54 - 17:19:39  FLIGHT NO. =  24
SITES FLOWN OVER:     18   5   6   3  13  21   8  15  23
PARAMETERS:     O3       NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:                 .008             .000     BMDL     29.4     19.4     3.0
MAXIMA:                 .139             .568       **     33.2     22.7     6.7       1427. FT.
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                          SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 239  YEAR = 1974  TUE, AUG 27  TIMES: 06:35:05 - 08:40:35  FLIGHT NO. =  25
SITES FLOWN OVER:     18   5    6   3   13  12    8  15  23
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                .003     .021     BMDL      BMDL      23.0      16.2       .3
MAXIMA:                .744     .791    2.940        .9      26.5      22.5      6.6      1798. FT.

JULIAN DAY = 239  YEAR = 1974  TUE, AUG 27  TIMES: 09:58:16 - 11:39:46  FLIGHT NO. =  26
SITES FLOWN OVER:     17  18    6   2    3   2   15  16
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                BMDL     .016     BMDL      BMDL      22.4      19.6       .6
MAXIMA:               1.370    1.210    2.500       3.9      28.4      22.8      3.5      2245. FT.

JULIAN DAY = 316  YEAR = 1974  TUE, NOV 12  TIMES: 09:20:00 - 10:41:40  FLIGHT NO. =  27
SITES FLOWN OVER:       5  20  21  15   16  23
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .004     BMDL     BMDL     BMDL      BMDL     -29.0       **        .3
MAXIMA:       .041     .008     .017     .007        .6     -11.4     -16.6      1.2      2223. FT.

JULIAN DAY = 316  YEAR = 1974  TUE, NOV 12  TIMES: 13:21:01 - 15:09:41  FLIGHT NO. =  28
SITES FLOWN OVER:       5   6   2  21   15  16   23
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .005     BMDL     .003     BMDL      BMDL       ***       ***       .1
MAXIMA:       .035     .034     .109     .005       9.0       ***       ***      1.2      2190. FT.

JULIAN DAY = 318  YEAR = 1974  THU, NOV 14  TIMES: 07:38:10 - 10:05:10  FLIGHT NO. =  29
SITES FLOWN OVER:       5   6  20  21   15  16   23
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL     BMDL     BMDL     BMDL        .1       ***       ***     BMDL
MAXIMA:       .082     .019     .041     .003        **       ***       ***      1.4      7258. FT.

JULIAN DAY = 318  YEAR = 1974  THU, NOV 14  TIMES: 11:33:45 - 13:09:45  FLIGHT NO. =  30
SITES FLOWN OVER:       5   6  20  21   15  16   23
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .006     BMDL     BMDL     BMDL      BMDL       ***       ***       .2
MAXIMA:         **     .007     .013     .004       5.2       ***       ***      2.5      2365. FT.

JULIAN DAY = 319  YEAR = 1974  FRI, NOV 15  TIMES: 11:50:30 - 14:24:55  FLIGHT NO. =  31
SITES FLOWN OVER:       5   6  20  21   15  16   23
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL     .000     .004     BMDL      BMDL       ***       ***     BMDL
MAXIMA:         **     .014     .029     .001       9.8       ***       ***     21.2      2410. FT.

JULIAN DAY = 320  YEAR = 1974  SAT, NOV 16  TIMES: 08:40:29 - 10:41:04  FLIGHT NO. =  32
SITES FLOWN OVER:     18  19  21  14     8   2   13   3    9
PARAMETERS:    O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL     BMDL     BMDL     BMDL      BMDL       ***       ***     BMDL
MAXIMA:       .065     .045     .053     .003       5.6       ***       ***      1.4      3313. FT.
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                      SUMMARY REPORT OF HELICOPTER DATA
           (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 320  YEAR = 1974  SAT, NOV 16  TIMES: 11:47:30 - 13:48:05  FLIGHT NO. =  33
SITES FLOWN OVER:     18  19   3   3  13  21  14   8   9
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        BMDL    BMDL    BMDL    BMDL    BMDL      ***     ***     BMDL
MAXIMA:        .049    .107    .137    .007     8.5      ***     ***      6.9     2076. FT.

JULIAN DAY = 324  YEAR = 1974  WED, NOV 20  TIMES: 07:20:10 - 09:26:00  FLIGHT NO. =  34
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        .002    BMDL    BMDL    .000    BMDL     -2.2   -18.4     BMDL
MAXIMA:          **    .017    .033    .020     1.0      9.5     5.4       .5     3680. FT.

JULIAN DAY = 324  YEAR = 1974  WED, NOV 20  TIMES: 11:51:05 - 13:53:35  FLIGHT NO. =  35
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        .003    BMDL    .000    BMDL    BMDL       **    -8.0     BMDL
MAXIMA:          **      **    .020    .085      .1     13.4     9.7      1.0     3598. FT.

JULIAN DAY = 325  YEAR = 1974  THU, NOV 21  TIMES: 07:49:20 - 09:54:20  FLIGHT NO. =  36
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        BMDL    BMDL    BMDL    BMDL    BMDL     -2.2               .1
MAXIMA:          **    .651    .675    .005     9.0      4.7              3.6     3464. FT.

JULIAN DAY = 325  YEAR = 1974  THU, NOV 21  TIMES: 10:10:15 - 12:06:55  FLIGHT NO. =  37
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        .009    BMDL    BMDL    BMDL    BMDL      1.1   -21.6     BMDL
MAXIMA:        .042    .023    .043    .124     1.9      7.7    -4.5       .9     3506. FT.

JULIAN DAY = 325  YEAR = 1974  THU, NOV 21  TIMES: 11:55:25 - 14:17:35  FLIGHT NO. =  38
SITES FLOWN OVER:     17   5   6  20  21  15  23  23
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        .013    BMDL    BMDL    BMDL             -2.2
MAXIMA:          **    .024    .048    .007              7.8                      3406. FT.

JULIAN DAY = 325  YEAR = 1974  THU, NOV 21  TIMES: 14:01:25 - 15:41:30  FLIGHT NO. =  39
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        .007    BMDL    .002    .001      .1      4.9   -11.0       .2
MAXIMA:        .057    .029    .052    .194     3.6     10.3    -1.5      1.2     2130. FT.

JULIAN DAY = 326  YEAR = 1974  FRI, NOV 22  TIMES: 13:39:35 - 15:45:35  FLIGHT NO. =  40
SITES FLOWN OVER:     18  19   3   2  13  21  14   8   9
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT     DPT     BSCAT    ALT (MSL)
MINIMA:        .015    BMDL    .004    BMDL             10.0     2.9       .2
MAXIMA:          **    .010    .046    .041             16.3    12.5      2.3     3498. FT.
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                      SUMMARY REPORT OF HELICOPTER DATA
           (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 327  YEAR = 1974  SAT, NOV 23  TIMES: 09:43:00 - 11:33:00  FLIGHT NO. =  41
SITES FLOWN OVER:     18  10   3   2  10  21   14   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .012    BMDL    BMDL     BMDL     BMDL      10.0    -20.0      .6
MAXIMA:       .071    .005    .030     .004      2.3      15.1      **      2.5      2103. FT.

JULIAN DAY = 329  YEAR = 1974  MON, NOV 25  TIMES: 07:41:15 - 10:00:35  FLIGHT NO. =  42
SITES FLOWN OVER:     18  19   3   2  13  21    4   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .003    BMDL    BMDL     BMDL               -4.8    -29.3    BMDL
MAXIMA:       .058    .035    .049     .003                 .3     -3.9     4.7      3333. FT.

JULIAN DAY = 329  YEAR = 1974  MON, NOV 25  TIMES: 12:30:25 - 14:51:50  FLIGHT NO. =  43
SITES FLOWN OVER:     18  19   3   2  13  21   14   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .002    BMDL    BMDL     BMDL     BMDL      -7.7      **     BMDL
MAXIMA:       .079    .024    .036     .002      6.4       5.2     -1.8     4.5      3515. FT.

JULIAN DAY = 329  YEAR = 1974  MON, NOV 25  TIMES: 14:53:25 - 16:34:15  FLIGHT NO. =  44
SITES FLOWN OVER:     18  19   3   2  13  21   14   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .002    BMDL    BMDL     .001     BMDL     -16.5      **     BMDL
MAXIMA:         **    .217    .104     .175      4.1       6.5      **      1.2      3510. FT.

JULIAN DAY = 330  YEAR = 1974  TUE, NOV 26  TIMES: 07:37:53 - 08:49:53  FLIGHT NO. =  45
SITES FLOWN OVER:     18  19   2   2  13
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .006    BMDL    BMDL     BMDL     BMDL      -2.9      **     BMDL
MAXIMA:       .054    .055    .081     .008     BMDL       2.5     -3.9     1.7      3416. FT.

JULIAN DAY = 330  YEAR = 1974  TUE, NOV 26  TIMES: 09:42:58 - 11:41:48  FLIGHT NO. =  46
SITES FLOWN OVER:     18  19   3   2  13  21   14   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .008    BMDL    BMDL     .001     BMDL      -4.9      **     BMDL
MAXIMA:         **    .106    .057     .103      2.5        **      **      8.1      4160. FT.

JULIAN DAY = 330  YEAR = 1974  TUE, NOV 26  TIMES: 13:10:35 - 15:40:15  FLIGHT NO. =  47
SITES FLOWN OVER:     18  19   3   2  13  21   14   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL    BMDL    BMDL     .001     BMDL     -14.3      **       .1
MAXIMA:         **    .033    .049     .069      7.2       8.8     -3.7     1.8      3601. FT.

JULIAN DAY = 330  YEAR = 1974  TUE, NOV 26  TIMES: 14:58:25 - 16:33:05  FLIGHT NO. =  48
SITES FLOWN OVER:     18  19   3   2  13  21   14   8   9
PARAMETERS:     O3      NO      NOX     SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       .002    BMDL    .004     BMDL                2.9    -11.6      .3
MAXIMA:       .048    .028    .055     .001                8.1     -3.9     1.5      1718. FT.
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                          SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 331  YEAR = 1974  WED, NOV 27  TIMES: 07:34:40 - 09:53:30  FLIGHT NO. =  49
SITES FLOWN OVER:     17    5    6  20   21   15   16   23
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .001     BMDL     BMDL              BMDL      -2.8     -16.8     BMDL
MAXIMA:        .061     .020     .044               **        4.6      -1.3      1.7      3790. FT.

JULIAN DAY = 331  YEAR = 1974  WED, NOV 27  TIMES: 09:50:39 - 11:27:49  FLIGHT NO. =  50
SITES FLOWN OVER:     17    5    6  20   21   15   16   23
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .019     BMDL     BMDL              BMDL     -16.5       **      BMDL
MAXIMA:        .079     .315     .035                .8       7.4       2.9      1.9      3312. FT.

JULIAN DAY = 331  YEAR = 1974  WED, NOV 27  TIMES: 11:28:25 - 13:07:45  FLIGHT NO. =  51
SITES FLOWN OVER:     17    5    6  20   21   15   16   23
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .031     BMDL     BMDL              BMDL       -.4     -15.8     BMDL
MAXIMA:        .057     .094     .093               1.0       7.8      -7.3       .8      2288. FT.

JULIAN DAY = 331  YEAR = 1974  WED, NOV 27  TIMES: 14:16:20 - 16:22:10  FLIGHT NO. =  52
SITES FLOWN OVER:     17    5    6  20   21   15    3
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .007     BMDL     BMDL              BMDL       4.6     -11.9       .1
MAXIMA:          **     .031     .056                .8       9.9      -5.4      2.6      2207. FT.

JULIAN DAY = 332  YEAR = 1974  THU, NOV 28  TIMES: 07:23:45 - 09:30:15  FLIGHT NO. =  53
SITES FLOWN OVER:     18   19    3   2   13   20   14    8    9
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .006     BMDL     .003              BMDL     -16.5     -22.3     BMDL
MAXIMA:          **     .160     .186               **       12.2        **       **      3514. FT.

JULIAN DAY = 332  YEAR = 1974  THU, NOV 28  TIMES: 10:44:35 - 12:21:25  FLIGHT NO. =  54
SITES FLOWN OVER:     17    5    6  20   21   15   16
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL     BMDL                        -2.2     -10.8       .3
MAXIMA:                 .088     .098                         5.5      -2.3      8.9      2147. FT.

JULIAN DAY = 332  YEAR = 1974  THU, NOV 28  TIMES: 13:45:26 - 16:29:56  FLIGHT NO. =  55
SITES FLOWN OVER:     18   19    3   2   13   21   14    8    9
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        BMDL     BMDL     .001              BMDL      -2.9     -15.3       .2
MAXIMA:        .073     .260     .282               **        5.6      -1.3      1.7      3705. FT.

JULIAN DAY = 333  YEAR = 1974  FRI, NOV 29  TIMES: 13:44:01 - 16:19:56  FLIGHT NO. =  56
SITES FLOWN OVER:      3
PARAMETERS:     03       NO      NOX      SO2       CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .012     BMDL     .014     .000     BMDL       2.0      -3.6
MAXIMA:        .051     .108     .124     .144      4.9       8.0        .9               2354. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 336  YEAR = 1974  MON, DEC  2  TIMES: 08:13:55 - 10:25:55  FLIGHT NO. =  57
SITES FLOWN OVER:     18  19   3   2  13  21  14   8   9
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:               BMDL    BMDL    BMDL            -4.8    -4.8
MAXIMA:               .086    .112    .001              .3     -.8             3274. FT.

JULIAN DAY = 336  YEAR = 1974  MON, DEC  2  TIMES: 10:32:05 - 12:10:05  FLIGHT NO. =  58
SITES FLOWN OVER:     18  19   3   2  13  21  14   8   9
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:               .001    .001    .000    BMDL      **   -18.2      .2
MAXIMA:               .188    .208    .351     2.6     1.0    -3.4     2.7     1955. FT.

JULIAN DAY = 336  YEAR = 1974  MON, DEC  2  TIMES: 13:13:01 - 15:51:36  FLIGHT NO. =  59
SITES FLOWN OVER:     18  19  18  19   3   2  13  21  14   8   9
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:               BMDL    BMDL    BMDL    BMDL    -3.5   -18.6
MAXIMA:               .881    .850    .006      **     3.5     -.3             3455. FT.

JULIAN DAY = 337  YEAR = 1974  TUE, DEC  3  TIMES: 07:20:02 - 09:20:02  FLIGHT NO. =  60
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:      BMDL    BMDL    BMDL    .000     BMDL   -14.1      **
MAXIMA:        **   1.230   1.250  11.000      5.0      **     3.7             3292. FT.

JULIAN DAY = 337  YEAR = 1974  TUE, DEC  3  TIMES: 14:01:35 - 15:42:30  FLIGHT NO. =  61
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:      .000    BMDL    BMDL    .000              -.6      **
MAXIMA:      .063    .093    .143    .975               **    -2.6             2033. FT.

JULIAN DAY = 338  YEAR = 1974  WED, DEC  4  TIMES: 11:00:10 - 12:31:05  FLIGHT NO. =  62
SITES FLOWN OVER:     99  99
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:      BMDL    BMDL    BMDL    .001     BMDL   -23.3   -26.6
MAXIMA:        **   1.320   1.310  15.600      7.4      **     2.5             2144. FT.

JULIAN DAY = 338  YEAR = 1974  WED, DEC  4  TIMES: 12:04:45 - 14:14:25  FLIGHT NO. =  63
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:      BMDL    BMDL    .001    BMDL     BMDL    -2.2   -24.9
MAXIMA:      .050    .067    .118    .010      9.1     3.0     1.3             2833. FT.

JULIAN DAY = 338  YEAR = 1974  WED, DEC  4  TIMES: 14:05:03 - 15:57:13  FLIGHT NO. =  64
SITES FLOWN OVER:     17   5   6  20  21  15  16  23
PARAMETERS:    03      NO     NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:      .009    BMDL    BMDL    .001     BMDL      **   -27.2
MAXIMA:        **    .218    .074    .108      3.3     6.4     3.5             3460. FT.
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                              SUMMARY REPORT OF HELICOPTER DATA
                    (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 339  YEAR = 1974  THU, DEC  5  TIMES: 07:31:50 - 09:50:05  FLIGHT NO. =  65
SITES FLOWN OVER:     18  19   3   2  13  21  14   8   9
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        BMDL      BMDL      .001      BMDL      BMDL       -2.2     -18.4       .2
MAXIMA:        .044      .234      .267      .010       8.4        8.9       -.3      3.8     3323. FT.

JULIAN DAY = 339  YEAR = 1974  THU, DEC  5  TIMES: 09:53:23 - 11:23:58  FLIGHT NO. =  66
SITES FLOWN OVER:     18  19   3   2  13  21  14   8  99   9
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .007      BMDL      BMDL      .001                   **     -10.3
MAXIMA:          **      .260      .075      .029                 21.3       9.7               2049. FT.

JULIAN DAY = 339  YEAR = 1974  THU, DEC  5  TIMES: 12:08:59 - 14:25:34  FLIGHT NO. =  67
SITES FLOWN OVER:     18  19   3   2  13  21  14   8   9
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .009      BMDL      BMDL      BMDL      BMDL        2.9     -11.6       .3
MAXIMA:        .055      .055      .084      .109        **        8.9        .8      2.8     3233. FT.

JULIAN DAY = 339  YEAR = 1974  THU, DEC  5  TIMES: 13:58:35 - 15:36:40  FLIGHT NO. =  68
SITES FLOWN OVER:     18  19   3   2  13  21  14   8   9
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        BMDL      BMDL      BMDL      .001      BMDL         **      -7.2
MAXIMA:        .073      .236      .102      .297        .5       11.7      11.5               2071. FT.

JULIAN DAY = 339  YEAR = 1974  THU, DEC  5  TIMES: 16:18:27 - 17:11:12  FLIGHT NO. =  69
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        BMDL      BMDL      .006      BMDL      BMDL        2.9      -3.3       .7
MAXIMA:        .038      .151      .203      .004       3.1        6.5        .3      1.8     2024. FT.

JULIAN DAY = 340  YEAR = 1974  FRI, DEC  6  TIMES: 07:17:15 - 09:18:20  FLIGHT NO. =  70
SITES FLOWN OVER:     18  19   6   3   2  21  14   8   9
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .001      BMDL      .001      .000      BMDL        5.2      -8.0
MAXIMA:        .058      .112      .147      .451       4.8       11.2       5.2               3468. FT.

JULIAN DAY = 340  YEAR = 1974  FRI, DEC  6  TIMES: 09:10:06 - 11:04:41  FLIGHT NO. =  71
SITES FLOWN OVER:     18  19   6   3   2  21  14   8   9
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .005      BMDL      BMDL      BMDL      BMDL        2.9      -8.7       .4
MAXIMA:        .061      .030      .067      .079       2.6       10.1       1.3      3.8     2907. FT.

JULIAN DAY = 340  YEAR = 1974  FRI, DEC  6  TIMES: 12:08:30 - 13:32:55  FLIGHT NO. =  72
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        BMDL      BMDL      .007      .001                  3.5      -7.0
MAXIMA:        .047      .323      .367     1.430                  9.1        .4               1424. FT.
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                        SUMMARY REPORT OF HELICOPTER DATA
              (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)
JULIAN DAY =  34  YEAR = 1975  MON, FEB  3  TIMES: 08:49:39 - 10:45:04  FLIGHT NO. =  73
SITES FLOWN OVER:     23  15  21   8  19
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL      .      -3.5   -22.0
MAXIMA:               .027    .047     .006               .4    -1.1              3290. FT.

JULIAN DAY =  34  YEAR = 1975  MON, FEB  3  TIMES: 13:34:15 - 15:20:25  FLIGHT NO. =  74
SITES FLOWN OVER:     17   3   2   6  20  36  19  18
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:               .001    .005     .000             -2.2    -4.2
MAXIMA:               .023    .044     .009              4.6     1.3              2825. FT.

JULIAN DAY =  35  YEAR = 1975  TUE, FEB  4  TIMES: 08:42:00 - 09:25:20  FLIGHT NO. =  75
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:       .003    BMDL    .012     BMDL      .6     -2.2             BMDL
MAXIMA:       .022    .007    .022     .001     3.0      2.0             BMDL      943. FT.

JULIAN DAY =  37  YEAR = 1975  THU, FEB  6  TIMES: 14:27:14 - 16:03:32  FLIGHT NO. =  76
SITES FLOWN OVER:     20   3   5   9  17  18  42  41
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:       .009    BMDL    BMDL     BMDL            -11.3
MAXIMA:       .061    .058    .106     .156             -5.1                      2384. FT.

JULIAN DAY =  38  YEAR = 1975  FRI, FEB  7  TIMES: 07:41:50 - 09:13:45  FLIGHT NO. =  77
SITES FLOWN OVER:     19  25  20  21
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL    BMDL    BMDL     BMDL            -11.4             BMDL
MAXIMA:       .059    .072    .098     .528             -7.5              1.6     3308. FT.

JULIAN DAY =  38  YEAR = 1975  FRI, FEB  7  TIMES: 08:48:56 - 10:26:01  FLIGHT NO. =  78
SITES FLOWN OVER:      6  18   5   3   8  15  16
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:       .028    BMDL    BMDL     BMDL    BMDL    -14.7     **      BMDL
MAXIMA:       .046    .051    .033     .003     1.6     -5.9   -12.1      1.7     3321. FT.

JULIAN DAY =  38  YEAR = 1975  FRI, FEB  7  TIMES: 10:57:50 - 12:29:10  FLIGHT NO. =  79
SITES FLOWN OVER:      6   5   3  17  23  40
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:       .013    BMDL    BMDL     BMDL             -8.8   -14.6     BMDL
MAXIMA:       .057    .028    .039     .502             -2.8    -5.2      2.7     3030. FT.

JULIAN DAY =  38  YEAR = 1975  FRI, FEB  7  TIMES: 13:29:12 - 16:07:27  FLIGHT NO. =  80
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:    03      NO     NOX      SO2      CO       OAT     DPT     BSCAT    ALT (MSL)
MINIMA:
MAXIMA:
                                                                                     FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  38  YEAR = 1975  FRI, FEB  7  TIMES: 14:05:06 - 14:58:46  FLIGHT NO. =  81
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:
MAXIMA:
                                                                                              FT.

JULIAN DAY =  39  YEAR = 1975  SAT, FEB  8  TIMES: 09:07:20 - 11:31:00  FLIGHT NO. =  82
SITES FLOWN OVER:       6  20  21  13   2   3  16  18
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        .003     BMDL     .001      .021               -7.0     -11.3       .4
MAXIMA:        .052     .145     .158      .077                 .8      -3.3      1.9      3260. FT.

JULIAN DAY =  39  YEAR = 1975  SAT, FEB  8  TIMES: 09:03:55 - 11:22:50  FLIGHT NO. =  83
SITES FLOWN OVER:       6  20  21   2   3  18
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        BMDL     BMDL     .001      BMDL      BMDL    -10.4     -11.6
MAXIMA:        .060     .494     .394      .026       9.2      **        **                4019. FT.

JULIAN DAY =  40  YEAR = 1975  SUN, FEB  9  TIMES: 08:49:30 - 10:53:35  FLIGHT NO. =  84
SITES FLOWN OVER:       6  20  21  13   2   3  16  18
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        BMDL     BMDL     BMDL      .000      BMDL    -20.2                BMDL
MAXIMA:        .023     .010     .019      .066       **     -13.4                 3.0      3231. FT.

JULIAN DAY =  40  YEAR = 1975  SUN, FEB  9  TIMES: 09:24:24 - 11:27:54  FLIGHT NO. =  85
SITES FLOWN OVER:       6   3   5   9  17  18  42  41
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        .005     BMDL     BMDL      BMDL      BMDL    -20.7
MAXIMA:        .057     .018     .029      .009       **     -14.1                          3292. FT.

JULIAN DAY =  40  YEAR = 1975  SUN, FEB  9  TIMES: 14:07:11 - 15:39:56  FLIGHT NO. =  86
SITES FLOWN OVER:       6   3   9  17  18  42  41
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        .008     .003     .010      BMDL        .3    -16.5     -22.3
MAXIMA:        .043     .031     .052      .017       2.8    -10.4     -13.9                2142. FT.

JULIAN DAY =  40  YEAR = 1975  SUN, FEB  9  TIMES: 13:57:24 - 15:42:34  FLIGHT NO. =  87
SITES FLOWN OVER:       5   3   5   9  17  18  42  41
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        BMDL     .002     .007      .000      BMDL    -15.1                  .4
MAXIMA:        .086     .409     .418      .656       2.0     -9.4                 11.1      1908. FT.

JULIAN DAY =  41  YEAR = 1975  MON, FEB 10  TIMES: 07:49:10 - 09:52:05  FLIGHT NO. =  88
SITES FLOWN OVER:      18   5   2  13  21  14  15  16  23
PARAMETERS:     O3       NO       NOX       SO2       CO       OAT       DPT      BSCAT     ALT (MSL)
MINIMA:        .002     BMDL     BMDL      BMDL      BMDL    -14.3       **       BMDL
MAXIMA:        .055     .025     .049      .005       1.5      8.8      -9.8        .6      4598. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  41  YEAR = 1975  MON, FEB 10  TIMES: 08:09:00 - 10:17:55  FLIGHT NO. =  89
SITES FLOWN OVER:     19  43  18  44   5   2  13  14
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL     BMDL     .000     BMDL     -29.4       **        .1
MAXIMA:                 .263     .285    1.180       **       2.1      -6.1     15.3      3387. FT.

JULIAN DAY =  41  YEAR = 1975  MON, FEB 10  TIMES: 13:20:18 - 14:43:03  FLIGHT NO. =  90
SITES FLOWN OVER:     10  43  18  44   5   2  13  14
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 .000     .002     .001               -2.7      -4.3       .6
MAXIMA:                 .019     .032     .065                3.5      -1.5     15.2      1941. FT.

JULIAN DAY =  41  YEAR = 1975  MON, FEB 10  TIMES: 13:16:40 - 14:58:00  FLIGHT NO. =  91
SITES FLOWN OVER:     18   5   2  13  21  14  15  16  23
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .016      BMDL     .004     BMDL     BMDL     -10.4     -11.6     BMDL
MAXIMA:       .042      .044     .058     .008      1.2       2.4      -4.6       .3      3058. FT.

JULIAN DAY =  43  YEAR = 1975  WED, FEB 12  TIMES: 08:37:45 - 10:14:55  FLIGHT NO. =  92
SITES FLOWN OVER:      6  20  21  13   2   3  16  18
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL     .005     .004     BMDL      -6.3                 .5
MAXIMA:                 .053     .098     .198      5.0       -.9                3.5      1893. FT.

JULIAN DAY =  43  YEAR = 1975  WED, FEB 12  TIMES: 12:14:28 - 14:02:08  FLIGHT NO. =  93
SITES FLOWN OVER:      6  20  21  13   2   3  16  18
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL     .003     .001               -4.0                 .5
MAXIMA:                 .016     .063     .078                 .3                3.1      1539. FT.

JULIAN DAY =  44  YEAR = 1975  THU, FEB 13  TIMES: 08:56:22 - 10:46:52  FLIGHT NO. =  94
SITES FLOWN OVER:     23  15  21   8   2   6  14   5
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL     BMDL     BMDL     BMDL      -7.5       **      BMDL
MAXIMA:                 .040     .065     .297       **      -1.6       **       4.8      2381. FT.

JULIAN DAY =  44  YEAR = 1975  THU, FEB 13  TIMES: 09:29:15 - 11:23:05  FLIGHT NO. =  95
SITES FLOWN OVER:      3   2   6  20  36  19  18  43
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL      .000     .000     BMDL     BMDL     -10.4     -18.4     BMDL
MAXIMA:       .083      .156     .176     .195       **      -1.0      -5.8      3.0      3277. FT.

JULIAN DAY =  44  YEAR = 1975  THU, FEB 13  TIMES: 13:01:51 - 14:13:06  FLIGHT NO. =  96
SITES FLOWN OVER:     41  42  18  17   9   5   4   6
PARAMETERS:     O3       NO      NOX      SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL     BMDL     .001       .9      -4.0      -6.4       .5
MAXIMA:                 .071     .072     .1[illegible]5       **       -.2      -2.6      1.9      1559. FT
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                         SUMMARY REPORT OF HELICOPTER DATA
                  (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  44  YEAR = 1975  THU, FEB 13  TIMES: 14:13:35 - 16:00:35  FLIGHT NO. =  97
SITES FLOWN OVER:     18  16   3   2  13  21  20   6
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .009     BMDL     .004     BMDL     BMDL      -9.0    -11.6     BMDL
MAXIMA:       .081     .014     .043     .004      4.4        .3     -4.2      2.7     1989. FT.

JULIAN DAY =  48  YEAR = 1975  MON, FEB 17  TIMES: 09:15:45 - 10:39:50  FLIGHT NO. =  98
SITES FLOWN OVER:     19  25  20  21
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .006     BMDL     .006     BMDL     BMDL      -2.2
MAXIMA:       .028     .009     .023     .002      1.8       4.2                       1990. FT.

JULIAN DAY =  48  YEAR = 1975  MON, FEB 17  TIMES: 10:53:25 - 12:18:35  FLIGHT NO. =  99
SITES FLOWN OVER:      6  18   5   3   8  15  16
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .006     BMDL     .007     BMDL     BMDL      -2.2
MAXIMA:       .028     .104     .134     .003      2.0       5.3                       2725. FT.

JULIAN DAY =  48  YEAR = 1975  MON, FEB 17  TIMES: 11:32:01 - 14:16:16  FLIGHT NO. = 100
SITES FLOWN OVER:      6   5   3   9  23  40  19  25  20  21
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .003     BMDL     .004     .002                 -.5     -2.7       .5
MAXIMA:       .037     .028     .040     .076                 4.6       .9      1.4     2080. FT.

JULIAN DAY =  48  YEAR = 1975  MON, FEB 17  TIMES: 13:36:55 - 14:56:45  FLIGHT NO. = 101
SITES FLOWN OVER:      6  18   5   3   8  15  16
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .003     BMDL     .007     BMDL     BMDL
MAXIMA:       .039     .048     .071     .004      1.4                                 2037. FT.

JULIAN DAY =  48  YEAR = 1975  MON, FEB 17  TIMES: 15:12:45 - 16:32:10  FLIGHT NO. = 102
SITES FLOWN OVER:      6   5   3   9  17  23  41
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .002     BMDL     .007     BMDL     BMDL      -2.2
MAXIMA:       .038     .025     .044     .001      1.5       5.0                       2257. FT.

JULIAN DAY =  49  YEAR = 1975  TUE, FEB 18  TIMES: 07:25:42 - 09:04:02  FLIGHT NO. = 103
SITES FLOWN OVER:     18  19  36  20   6   2   3
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .002     BMDL     .001     .001     BMDL        .3     -2.0       .8
MAXIMA:       .048     .136     .276     .663       **       3.0       .0      9.6     1609. FT.

JULIAN DAY =  50  YEAR = 1975  WED, FEB 19  TIMES: 07:22:15 - 09:17:00  FLIGHT NO. = 104
SITES FLOWN OVER:      6  20  13   2   3  16  18  41
PARAMETERS:    O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:                BMDL     BMDL     BMDL     BMDL      -5.9     -8.1       .7
MAXIMA:                .159     .151     .212       **       -.5     -4.6      3.4     1847. FT.
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                        SUMMARY REPORT OF HELICOPTER DATA
                (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  50  YEAR = 1975  WED, FEB 19  TIMES: 11:56:32 - 15:45:02  FLIGHT NO. = 105
SITES FLOWN OVER:      1
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:                BMDL    BMDL     BMDL             -5.2    -27.0     BMDL
MAXIMA:                .769    .875   11.600              3.0     -5.1      9.3     3788. FT.

JULIAN DAY =  51  YEAR = 1975  THU, FEB 20  TIMES: 07:29:06 - 11:29:01  FLIGHT NO. = 106
SITES FLOWN OVER:     43  43  43  43  43
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        BMDL    BMDL    BMDL     BMDL     BMDL    -2.2    -17.0
MAXIMA:        .053   1.240   1.240     .712      2.4      **       **              4553. FT.

JULIAN DAY =  51  YEAR = 1975  THU, FEB 20  TIMES: 07:40:07 - 09:12:42  FLIGHT NO. = 107
SITES FLOWN OVER:     43  18  19  36  20   6   2   3
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .033    BMDL    BMDL     BMDL              -.6    -18.2     BMDL
MAXIMA:        .051    .116    .177     .413              5.2     -1.5      2.4     2892. FT.

JULIAN DAY =  51  YEAR = 1975  THU, FEB 20  TIMES: 10:45:05 - 13:00:55  FLIGHT NO. = 108
SITES FLOWN OVER:     43  43  43  43  43  43  43  43  43  43  43  43  43  43  43  43  43
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:                BMDL    BMDL     .001               .8    -14.4       .1
MAXIMA:                .007    .014     .001             10.6     -5.7      1.2     2907. FT.

JULIAN DAY =  51  YEAR = 1975  THU, FEB 20  TIMES: 13:00:55 - 14:43:10  FLIGHT NO. = 109
SITES FLOWN OVER:      5  19   6   2   8  21  15  23
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .025    BMDL    BMDL     BMDL     BMDL    -2.2    -16.6
MAXIMA:        .060    .021    .045     .008       .6    12.2     -1.1              3381. FT.

JULIAN DAY =  51  YEAR = 1975  THU, FEB 20  TIMES: 14:52:15 - 15:32:35  FLIGHT NO. = 110
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:
MAXIMA:                                                                                  FT.

JULIAN DAY =  52  YEAR = 1975  FRI, FEB 21  TIMES: 14:16:34 - 16:11:09  FLIGHT NO. = 111
SITES FLOWN OVER:      1   2   3   4   5   6   7   8   9
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .002    BMDL    .001     BMDL     BMDL     5.6     -3.6
MAXIMA:        .079    .457    .561    1.050      8.3    17.9      2.9              4977. FT.

JULIAN DAY =  57  YEAR = 1975  WED, FEB 26  TIMES: 08:10:10 - 09:48:00  FLIGHT NO. = 112
SITES FLOWN OVER:      6  20  21   2   3  16  18
PARAMETERS:     O3      NO      NOX      SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:                BMDL    BMDL     BMDL     BMDL    -2.2    -20.0     BMDL
MAXIMA:                .060    .089     . 68       .7     4.2     -5.8       .8     3338. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                  (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  57  YEAR = 1975  WED, FEB 26  TIMES: 08:25:55 - 11:46:50  FLIGHT NO. = 113
SITES FLOWN OVER:       6  20  21   3    2   3  16  18    6   3    5   9  17  18  42  41
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .001      BMDL      BMDL      BMDL      BMDL       -3.5     -20.0
MAXIMA:        .081      .089      .123      .008       1.6        6.7      -5.2               4102. FT.

JULIAN DAY =  57  YEAR = 1975  WED, FEB 26  TIMES: 09:58:30 - 11:02:15  FLIGHT NO. = 114
SITES FLOWN OVER:       6   3   5   9  17  18  42  41
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                  BMDL      BMDL      BMDL        .1         .6     -10.2        .2
MAXIMA:                  .140      .179      .281       2.6        4.6      -5.4       1.2     2001. FT.

JULIAN DAY =  57  YEAR = 1975  WED, FEB 26  TIMES: 11:43:54 - 14:35:09  FLIGHT NO. = 115
SITES FLOWN OVER:       6  20  21  13    2   3  16  18    6   3    5   9  18  42  40
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                  BMDL      BMDL      BMDL      BMDL         .9     -12.9        .1
MAXIMA:                  .094      .120      .085       8.0         **       1.8       1.2     2046. FT.

JULIAN DAY =  58  YEAR = 1975  THU, FEB 27  TIMES: 06:54:55 - 09:29:00  FLIGHT NO. = 116
SITES FLOWN OVER:     10  20
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                  BMDL      BMDL      BMDL      BMDL       -4.8                  .2
MAXIMA:                  .788      .871     2.390       3.5        3.0                 7.1     3497. FT.

JULIAN DAY =  58  YEAR = 1975  THU, FEB 27  TIMES: 13:21:03 - 14:50:03  FLIGHT NO. = 117
SITES FLOWN OVER:     23  16  15  14  21  13   2   5  18
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                  BMDL      BMDL      .001      BMDL        -.2                  .1
MAXIMA:                  .028      .040      .001       3.2        5.9                 1.1     1973. FT.

JULIAN DAY =  59  YEAR = 1975  FRI, FEB 28  TIMES: 08:05:55 - 09:59:05  FLIGHT NO. = 118
SITES FLOWN OVER:       6  20  21  13    2   3  16  18
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                  BMDL      BMDL      BMDL      BMDL       -1.6                  .1
MAXIMA:                  .018      .037      .073       2.7        4.8                 2.5     3389. FT.

JULIAN DAY =  59  YEAR = 1975  FRI, FEB 28  TIMES: 09:03:46 - 10:48:26  FLIGHT NO. = 119
SITES FLOWN OVER:       6   3   5   9  17  18  42  41
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .014      BMDL      BMDL      BMDL      BMDL       -2.2     -18.4        .1
MAXIMA:        .058      .079      .094      .007       6.3        6.0        .1       2.1     3409. FT.

JULIAN DAY =  59  YEAR = 1975  FRI, FEB 28  TIMES: 12:26:45 - 13:53:45  FLIGHT NO. = 120
SITES FLOWN OVER:       6  20  21  13    2   3  16  18
PARAMETERS:      O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                  BMDL      BMDL      BMDL      BMDL         .9                  .3
MAXIMA:                  .054      .114      .[illegible]5       1.8        7.1                 1.7     2063. FT.
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                    SUMMARY REPORT OF HELICOPTER DATA
         (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  60  YEAR = 1975  SAT, MAR  1  TIMES: 09:14:12 - 12:16:17  FLIGHT NO. = 121
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:                 BMDL      BMDL      .000      BMDL      -5.1      -8.4       .5
MAXIMA:                 .351      .384      .535       9.3       3.4       -.3      2.3     2853. FT.

JULIAN DAY =  61  YEAR = 1975  SUN, MAR  2  TIMES: 08:09:55 - 09:25:30  FLIGHT NO. = 122
SITES FLOWN OVER:       6  20  21  13   2   3
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .029      BMDL      BMDL      BMDL      BMDL     -13.7     -18.4     BMDL
MAXIMA:       .050      .009      .023      .004       6.5      -5.7     -10.2      1.6     1973. FT.

JULIAN DAY =  63  YEAR = 1975  TUE, MAR  4  TIMES: 06:39:01 - 09:53:11  FLIGHT NO. = 123
SITES FLOWN OVER:      23  16  15  14  21  13   2   5  18  14  13   2   5  18  43  19
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .000      BMDL      BMDL      BMDL      BMDL      -9.0     -18.4     BMDL
MAXIMA:       .063      .616      .664      .955       5.4        .1      -4.8      6.2     2104. FT.

JULIAN DAY =  63  YEAR = 1975  TUE, MAR  4  TIMES: 07:11:15 - 09:44:35  FLIGHT NO. = 124
SITES FLOWN OVER:      23  16  15  14  21  13   2   5  18  14  13   2   5  18  43  19
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL      BMDL      BMDL      .000      BMDL      -5.3                 .4
MAXIMA:       .076     1.160     1.210     3.260       7.8      -1.1                16.8     2423. FT.

JULIAN DAY =  63  YEAR = 1975  TUE, MAR  4  TIMES: 11:59:40 - 14:46:45  FLIGHT NO. = 125
SITES FLOWN OVER:      23  16  15  14  21  13   2   5  18  14  13   2   5  18  43  19
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .014      BMDL      .005      .000      BMDL      -2.9     -17.7       .1
MAXIMA:       .066      .066      .150      .168        **       5.5      -5.4      8.1     2168. FT.

JULIAN DAY =  63  YEAR = 1975  TUE, MAR  4  TIMES: 12:21:41 - 14:42:36  FLIGHT NO. = 126
SITES FLOWN OVER:      23  16  15  14  21  13   2   5  18  14  13   2   5  18  43  19
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .009      .004      .016      .000      BMDL      -2.2                 .7
MAXIMA:       .095      .203      .229      .256       5.7       4.0                 6.5     2016. FT.

JULIAN DAY =  64  YEAR = 1975  WED, MAR  5  TIMES: 07:06:00 - 10:40:50  FLIGHT NO. = 127
SITES FLOWN OVER:       5  19   6   2   8  21  99  70  71   5  15  23
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .005                          BMDL      BMDL      -2.2     -11.6       .3
MAXIMA:       .056                          .296       9.3       6.8      -1.1      5.4     2675. FT.

JULIAN DAY =  64  YEAR = 1975  WED, MAR  5  TIMES: 07:03:22 - 10:20:42  FLIGHT NO. = 128
SITES FLOWN OVER:      43  18  19  36  20   2   2   3   5  19   6   2   8  21  15  23
PARAMETERS:    O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:       .016      BMDL      BMDL      .000      BMDL        .6                  .4
MAXIMA:       .049      .101      .112      .096        **       5.9                 1.8     2046. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  64  YEAR = 1975  WED, MAR  5  TIMES: 13:04:42 - 15:50:12  FLIGHT NO. = 129
SITES FLOWN OVER:      5  19    6   2    8  21   15  23   43  18   19  36   20    6    2    2
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .031      BMDL      .001      .000                 7.1                 .5
MAXIMA:        .087      .021      .050      .048                14.9                1.6     1930. FT.

JULIAN DAY = 194  YEAR = 1975  SUN, JUL 13  TIMES: 13:06:46 - 14:55:51  FLIGHT NO. = 130
SITES FLOWN OVER:      SEE FLIGHT DESCRIPTION
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .002      BMDL      BMDL      BMDL      BMDL      10.0       4.6       .1
MAXIMA:        .052      .359      .420      .286       2.3      20.2       **       6.8     1787. FT.

JULIAN DAY = 194  YEAR = 1975  SUN, JUL 13  TIMES: 13:04:11 - 15:02:16  FLIGHT NO. = 131
SITES FLOWN OVER:     99
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .010      BMDL      BMDL      BMDL                 4.4                 .3
MAXIMA:        .052      .359      .364      .664                11.4                6.2     1776. FT.

JULIAN DAY = 195  YEAR = 1975  MON, JUL 14  TIMES: 07:26:09 - 09:21:59  FLIGHT NO. = 132
SITES FLOWN OVER:      2    2    3    5
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .038      BMDL      BMDL      .000      BMDL      16.4       7.4       .5
MAXIMA:        .050      .155      .219      .065       4.6      20.7      13.4      6.8     3597. FT.

JULIAN DAY = 195  YEAR = 1975  MON, JUL 14  TIMES: 08:01:51 - 10:10:16  FLIGHT NO. = 133
SITES FLOWN OVER:     25    2    3    6    5
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .007      BMDL      BMDL      .001      BMDL      14.7       8.2       .3
MAXIMA:        .048      .106      .264      .034       1.9      21.9      15.0      5.1     2344. FT.

JULIAN DAY = 195  YEAR = 1975  MON, JUL 14  TIMES: 11:13:42 - 12:54:12  FLIGHT NO. = 134
SITES FLOWN OVER:     25    2    3    6    5
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .012      BMDL      BMDL      .000      BMDL      15.0      10.0       .4
MAXIMA:        .069      .062      .222      .025       **       27.4      16.3      2.3     3053. FT.

JULIAN DAY = 195  YEAR = 1975  MON, JUL 14  TIMES: 12:20:25 - 13:53:05  FLIGHT NO. = 135
SITES FLOWN OVER:      2    3    6    7   25
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .038      BMDL      BMDL      BMDL      BMDL       **        **        .1
MAXIMA:        .077      .011      .034      .054       2.2      27.3      23.5      1.5     2199. FT.

JULIAN DAY = 196  YEAR = 1975  TUE, JUL 15  TIMES: 08:59:55 - 10:17:25  FLIGHT NO. = 136
SITES FLOWN OVER:     25    2    3    6    5    2    3    6    5
PARAMETERS:     O3        NO       NOX       SO2        CO        OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .002      BMDL      .000      BMDL      BMDL      19.7      10.0       .6
MAXIMA:        .118      .443      .544      .270       4.8      26.6      17.5      8.9     3665. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 196  YEAR = 1975  TUE, JUL 15  TIMES: 11:18:08 - 14:15:53  FLIGHT NO. = 137
SITES FLOWN OVER:     25   2   3   6   5   2   3   6   5  25
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .032     BMDL     BMDL     BMDL     BMDL      **       8.9      .2
MAXIMA:        .086     .114     .148     .071      3.6     28.9      **      2.1     3513. FT.

JULIAN DAY = 196  YEAR = 1975  TUE, JUL 15  TIMES: 13:18:25 - 15:26:25  FLIGHT NO. = 138
SITES FLOWN OVER:     33  55  66  88
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .037     BMDL     BMDL     .000     BMDL      **      11.2      .3
MAXIMA:        .157     .013     .060     .036      2.1     29.5     27.9     3.1     4686. FT.

JULIAN DAY = 197  YEAR = 1975  WED, JUL 16  TIMES: 07:17:03 - 08:30:33  FLIGHT NO. = 139
SITES FLOWN OVER:     24   2   3
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .033     BMDL     BMDL     .000     BMDL      **       **       .1
MAXIMA:        .065     .077     .110     .041      2.4     25.4      **      4.7     3607. FT.

JULIAN DAY = 197  YEAR = 1975  WED, JUL 16  TIMES: 08:03:03 - 09:48:28  FLIGHT NO. = 140
SITES FLOWN OVER:     24   2   3   6   5
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .014     BMDL     .002     .000     BMDL     19.6      8.9     1.0
MAXIMA:        .134     .049     .106     .113      3.4     28.0     17.6     7.2     3845. FT.

JULIAN DAY = 197  YEAR = 1975  WED, JUL 16  TIMES: 11:21:34 - 12:57:14  FLIGHT NO. = 141
SITES FLOWN OVER:     24   2   3   6   5
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .023     BMDL     BMDL     .000     BMDL     22.0     10.6     1.9
MAXIMA:        .097     .064     .111     .001      4.8     30.6     16.7     2.9     2443. FT.

JULIAN DAY = 197  YEAR = 1975  WED, JUL 16  TIMES: 12:27:35 - 13:45:00  FLIGHT NO. = 142
SITES FLOWN OVER:      2   3   6   5  24
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .059     BMDL     BMDL     BMDL       .4     23.7              2.0
MAXIMA:        .088     .118     .135     .070      3.3     27.7              8.6     2553. FT.

JULIAN DAY = 198  YEAR = 1975  THU, JUL 17  TIMES: 07:15:34 - 08:59:19  FLIGHT NO. = 143
SITES FLOWN OVER:     25   2   3   6   5
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .006     BMDL     BMDL     BMDL     BMDL     22.5              2.0
MAXIMA:        .077     .445     .500    1.420      3.5     26.8              8.2     2101. FT.

JULIAN DAY = 198  YEAR = 1975  THU, JUL 17  TIMES: 09:09:08 - 10:38:18  FLIGHT NO. = 144
SITES FLOWN OVER:     25   2   3   6   5
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:        .017     BMDL     .002     .000     BMDL     22.4     15.0     2.4
MAXIMA:        .099     .079     .149     .059      1.8     29.0     20.7     8.7     2160. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 198  YEAR = 1975  THU, JUL 17  TIMES: 11:17:46 - 13:11:41  FLIGHT NO. = 145
SITES FLOWN OVER:      25   2    3    6    5
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .035     BMDL    BMDL     BMDL     BMDL      19.2              2.3
MAXIMA:       .113     .178    .205     .201      2.9      31.0             13.0     4177. FT.

JULIAN DAY = 198  YEAR = 1975  THU, JUL 17  TIMES: 12:47:47 - 13:43:17  FLIGHT NO. = 146
SITES FLOWN OVER:       2    6    5
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .041     BMDL    .003     BMDL     BMDL      26.2     14.6     1.3
MAXIMA:       .098     .013    .074     .005      **       33.1     20.9     4.7      1749. FT.

JULIAN DAY = 199  YEAR = 1975  FRI, JUL 18  TIMES: 07:04:53 - 09:55:08  FLIGHT NO. = 147
SITES FLOWN OVER:      24   2    3    6    5    2    3    6
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .012     BMDL    BMDL     BMDL     BMDL      22.1     13.6     1.3
MAXIMA:       .071     .087    .127     .101      2.9      28.4     21.6     3.1      3681. FT.

JULIAN DAY = 199  YEAR = 1975  FRI, JUL 18  TIMES: 08:39:36 - 11:24:31  FLIGHT NO. = 148
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL     BMDL    BMDL     .000     BMDL      22.4     12.0     1.9
MAXIMA:       .120     .047    .055     .002      9.6      31.2     22.5     3.6      3606. FT.

JULIAN DAY = 199  YEAR = 1975  FRI, JUL 18  TIMES: 11:34:25 - 13:55:05  FLIGHT NO. = 149
SITES FLOWN OVER:       2    3    6    5    2    3    6    5   25
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .036     BMDL    BMDL     BMDL     BMDL      23.2     13.6     1.2
MAXIMA:       .075     .240    .271     .097      2.8      30.6     20.7     4.7      2404. FT.

JULIAN DAY = 199  YEAR = 1975  FRI, JUL 18  TIMES: 11:52:11 - 13:49:11  FLIGHT NO. = 150
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .042     BMDL    BMDL     .001       .0      21.9     15.5     1.2
MAXIMA:       .103     .016    .023     .007      2.4      32.5     22.0     3.8      3561. FT.

JULIAN DAY = 200  YEAR = 1975  SAT, JUL 19  TIMES: 07:07:16 - 09:09:46  FLIGHT NO. = 151
SITES FLOWN OVER:      25   2    3    6    5
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .006     BMDL    BMDL     .000     BMDL      21.7     17.0      .6
MAXIMA:       .039     .057    .074     .108      2.8      27.1     22.6     2.1      2172. FT.

JULIAN DAY = 200  YEAR = 1975  SAT, JUL 19  TIMES: 08:18:28 - 09:48:08  FLIGHT NO. = 152
SITES FLOWN OVER:      25   2    3    6    5
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .012     BMDL    BMDL     BMDL     BMDL      21.6     15.6      .4
MAXIMA:       .029     .030    .057     .001      3.9      30.7     21.6     2.1      3472. FT.
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                        SUMMARY REPORT OF HELICOPTER DATA
             (GAS DATA IN PPM, OAT AND DPT IN DFG C., BSCAT IN 1/M)

JULIAN DAY = 200  YEAR = 1975  SAT, JUL 19  TIMES: 11:19:23 - 12:52:03  FLIGHT NO. = 153
SITES FLOWN OVER:     25   2   3   6   5
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .015    BMDL    BMDL    .000     BMDL    26.2     20.0      .8
MAXIMA:       .063    .058    .102    .002      1.0    33.8     23.2     2.1     2217. FT.

JULIAN DAY = 200  YEAR = 1975  SAT, JUL 19  TIMES: 12:34:28 - 14:10:13  FLIGHT NO. = 154
SITES FLOWN OVER:      2   3   6   5  25
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .037    BMDL    BMDL    .000     BMDL    25.9     16.8      .6
MAXIMA:       .062    .042    .066    .048      3.3    31.2     23.0     2.2     2091. FT.

JULIAN DAY = 203  YEAR = 1975  TUE, JUL 22  TIMES: 07:59:00 - 09:50:05  FLIGHT NO. = 155
SITES FLOWN OVER:     23   3   6   5
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .011    BMDL    BMDL    BMDL     BMDL    22.1     11.7      .7
MAXIMA:       .063    .378    .393    .038      3.1    28.2     20.2     3.8     3125. FT.

JULIAN DAY = 203  YEAR = 1975  TUE, JUL 22  TIMES: 09:18:24 - 10:36:44  FLIGHT NO. = 156
SITES FLOWN OVER:     23   2   3   6   5
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .006    BMDL    BMDL    BMDL     BMDL    23.1     14.6      .2
MAXIMA:       .065    .110    .163    .004      2.0    30.1     19.2     4.5     1811. FT.

JULIAN DAY = 203  YEAR = 1975  TUE, JUL 22  TIMES: 11:27:05 - 13:17:05  FLIGHT NO. = 157
SITES FLOWN OVER:     24   2   3   6   5
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .044    BMDL    BMDL    BMDL     BMDL    22.7      8.5      .8
MAXIMA:       .116    .145    .206    .051      2.4    32.8     20.9     3.4     3696. FT.

JULIAN DAY = 203  YEAR = 1975  TUE, JUL 22  TIMES: 13:15:31 - 14:32:26  FLIGHT NO. = 158
SITES FLOWN OVER:      2   3   6   5  24
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .063    BMDL    BMDL    BMDL     BMDL    26.2     14.6     1.0
MAXIMA:       .121    .030    .055    .004       .8    33.8     21.6     2.9     2212. FT.

JULIAN DAY = 204  YEAR = 1975  WED, JUL 23  TIMES: 07:14:40 - 09:03:05  FLIGHT NO. = 159
SITES FLOWN OVER:     24   2   3   6   5
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .022                    .000       .1    27.5     18.8      .9
MAXIMA:       .064                    .071      2.5    31.0     23.4     6.9     2689. FT.

JULIAN DAY = 204  YEAR = 1975  WED, JUL 23  TIMES: 08:13:53 - 10:06:33  FLIGHT NO. = 160
SITES FLOWN OVER:     24   2   3   6   5
PARAMETERS:    03      NO      NOX     SO2      CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .020    BMDL    .001    BMDL     BMDL    26.2     19.6      .8
MAXIMA:       .174    .353    .343    .020      5.4    33.8     24.6     6.6     2200. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
               (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 204  YEAR = 1975  WED, JUL 23  TIMES: 11:32:01 - 14:47:31  FLIGHT NO. = 161
SITES FLOWN OVER:     24   2   3   6   5   2   3   6   5  24
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL      BMDL      BMDL      BMDL      BMDL      23.1      10.0        .1
MAXIMA:       .068      .338      .403      .418       2.7      35.0      25.3       4.2     1822. FT.

JULIAN DAY = 205  YEAR = 1975  THU, JUL 24  TIMES: 07:00:35 - 10:03:15  FLIGHT NO. = 162
SITES FLOWN OVER:     25   2   3   6   5   2   3   6   5  25
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .009      BMDL      BMDL      BMDL      BMDL      21.3      17.5        .6
MAXIMA:       .053     1.420     1.340      .002       2.9      26.0      21.8       2.9     1968. FT.

JULIAN DAY = 205  YEAR = 1975  THU, JUL 24  TIMES: 11:22:25 - 14:18:40  FLIGHT NO. = 163
SITES FLOWN OVER:     22   2   3   6   5   2   3   6   5  22
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .002      BMDL      .002      BMDL      BMDL        **      19.6        .2
MAXIMA:       .080      .240      .294      .047       7.1      33.6        **       3.4     2188. FT.

JULIAN DAY = 205  YEAR = 1975  THU, JUL 24  TIMES: 13:50:09 - 16:19:14  FLIGHT NO. = 164
SITES FLOWN OVER:     30  31  32  33  34  35  36  37  38  39  40  41  42
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .001      BMDL      BMDL      .001      BMDL      24.8      18.0        .8
MAXIMA:       .049      .107      .181      .135       3.0      28.6      21.9       1.7     1828. FT.

JULIAN DAY = 206  YEAR = 1975  FRI, JUL 25  TIMES: 07:17:19 - 09:25:44  FLIGHT NO. = 165
SITES FLOWN OVER:     22  14   2   3   6   5
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .010      BMDL      BMDL      BMDL      BMDL      15.4        **        .1
MAXIMA:       .066     1.340     1.330     5.300       2.9      23.5      18.0      10.9     5927. FT.

JULIAN DAY = 206  YEAR = 1975  FRI, JUL 25  TIMES: 08:10:48 - 09:58:43  FLIGHT NO. = 166
SITES FLOWN OVER:     22   2   3   6   5  14
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .016      BMDL      BMDL      BMDL      BMDL      15.5      10.0        .2
MAXIMA:       .070     1.390     1.400     3.110       2.4      28.5      21.6      14.1     6059. FT.

JULIAN DAY = 206  YEAR = 1975  FRI, JUL 25  TIMES: 11:11:59 - 13:20:49  FLIGHT NO. = 167
SITES FLOWN OVER:     22   2   3   6   5   2   3   6   5  22
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .046      BMDL      BMDL      .000      BMDL      22.1       9.4       1.1
MAXIMA:         **      .016      .033      .035       2.7      26.5      15.0       2.1     1662. FT.

JULIAN DAY = 206  YEAR = 1975  FRI, JUL 25  TIMES: 12:55:40 - 14:41:25  FLIGHT NO. = 168
SITES FLOWN OVER:     SEE FLIGHT DESCPIPTION
PARAMETERS:     O3        NO       NOX       SO2        CO       OAT       DPT     BSCAT    ALT (MSL)
MINIMA:       .028      BMDL      .000      BMDL      BMDL      26.2      10.0        .7
MAXIMA:       .172      .048      .087      .083       1.0      29.5      16.3       2.2     1831. FT
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                       SUMMARY REPORT OF HELICOPTER DATA
            (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 207  YEAR = 1975  SAT, JUL 26  TIMES: 07:06:20 - 09:28:05  FLIGHT NO. = 169
SITES FLOWN OVER:     14  23   2   3   6   5  14
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .008    BMDL    BMDL    .000     BMDL    14.3     **      .3
MAXIMA:       .070    .214    .282    .148      3.8    23.9    18.8     7.6     6032. FT.

JULIAN DAY = 207  YEAR = 1975  SAT, JUL 26  TIMES: 08:21:44 - 10:14:34  FLIGHT NO. = 170
SITES FLOWN OVER:     14  23   2   3   6   5  14
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .038    BMDL    .000    BMDL     BMDL    14.6     2.9    BMDL
MAXIMA:       .160    .045    .093    .025      2.5    28.9    23.2     3.7     6461. FT.

JULIAN DAY = 207  YEAR = 1975  SAT, JUL 26  TIMES: 11:25:38 - 14:01:53  FLIGHT NO. = 171
SITES FLOWN OVER:     23   2   3   6   5   2   3   6   5  23
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .057    BMDL    BMDL    .000     BMDL    21.3             1.2
MAXIMA:       .145    .076    .151    .095      4.3    26.6             3.1     2113. FT.

JULIAN DAY = 208  YEAR = 1975  SUN, JUL 27  TIMES: 08:22:40 - 10:44:15  FLIGHT NO. = 172
SITES FLOWN OVER:     25   2   3   6   5   2   3   6   5
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .001    BMDL    BMDL    BMDL     BMDL    21.4    10.9      .7
MAXIMA:       .078    .833    .884    .009      9.5    32.3    22.5     2.8     2490. FT.

JULIAN DAY = 208  YEAR = 1975  SUN, JUL 27  TIMES: 11:16:07 - 13:31:42  FLIGHT NO. = 173
SITES FLOWN OVER:     25   2   3   6   2   3   6   5  25
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .027    BMDL            BMDL     BMDL    26.6    16.3     1.7
MAXIMA:       .101    .032            .483      1.9    31.0    21.3     3.6     1641. FT.

JULIAN DAY = 209  YEAR = 1975  MON, JUL 28  TIMES: 07:15:39 - 09:49:19  FLIGHT NO. = 174
SITES FLOWN OVER:     25   2   3   6   5   2   3   6   5  25
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .002    BMDL            .000     BMDL    23.1    18.3     1.3
MAXIMA:        **     .627           1.650      4.3    28.4    24.1    11.1     1760. FT.

JULIAN DAY = 209  YEAR = 1975  MON, JUL 28  TIMES: 13:19:47 - 15:26:57  FLIGHT NO. = 175
SITES FLOWN OVER:     22   2   3   6   5   2   3   6   5  22
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .036    BMDL            BMDL     BMDL    27.7    15.8     1.0
MAXIMA:       .098    .060            .578      2.8    31.8    20.5     7.5     1668. FT.

JULIAN DAY = 210  YEAR = 1975  TUE, JUL 29  TIMES: 07:08:31 - 09:05:01  FLIGHT NO. = 176
SITES FLOWN OVER:     24   2
PARAMETERS:    O3      NO      NOX     SO2      CO      OAT     DPT    BSCAT    ALT (MSL)
MINIMA:       .011    BMDL    BMDL    .000     BMDL    22.7    18.3     1.6
MAXIMA:       .072    .054    .103    .109      1.8    26.8    22.6     5.6     2036. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 210  YEAR = 1975  TUE, JUL 29  TIMES: 12:55:00 - 15:09:45  FLIGHT NO. = 177
SITES FLOWN OVER:     23   2   3   3    6   5    2   3    6   5  23
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:       .039     BMDL      BMDL     .013      BMDL      27.4     14.1      3.4
MAXIMA:       .105     .099      .149     .047       2.4      31.1     20.5      8.7      1665. FT.

JULIAN DAY = 211  YEAR = 1975  WED, JUL 30  TIMES: 11:11:45 - 12:29:55  FLIGHT NO. = 178
SITES FLOWN OVER:     23   2   3   6    5
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:                BMDL      BMDL     BMDL      BMDL      26.9     19.6      2.7
MAXIMA:                .014      .028     .038       1.7      32.0     22.8      5.5      1665. FT.

JULIAN DAY = 211  YEAR = 1975  WED, JUL 30  TIMES: 11:13:13 - 14:28:59  FLIGHT NO. = 179
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:                BMDL      BMDL     BMDL      BMDL      21.4     14.6      1.6
MAXIMA:                .042      .095     .078       4.3      33.1     23.7      6.2      2722. FT.

JULIAN DAY = 212  YEAR = 1975  THU, JUL 31  TIMES: 08:04:05 - 09:59:10  FLIGHT NO. = 180
SITES FLOWN OVER:     24   2   3   6    5   2    3   6    5  24
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:                BMDL      .002     .003      BMDL      21.4     14.6       .2
MAXIMA:                .078      .113     .099       5.6      28.0     20.4      8.5      2067. FT.

JULIAN DAY = 212  YEAR = 1975  THU, JUL 31  TIMES: 12:11:49 - 14:01:39  FLIGHT NO. = 181
SITES FLOWN OVER:     23   2   3   6    5   2    3   6    5  23
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:                BMDL      .006     BMDL                26.2     14.6       .3
MAXIMA:                .022      .068     .061                31.2     19.2      2.3      1598. FT.

JULIAN DAY = 215  YEAR = 1975  SUN, AUG  3  TIMES: 11:18:32 - 12:14:57  FLIGHT NO. = 182
SITES FLOWN OVER:     22   2   3   6
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:       .044     BMDL      BMDL     .000      BMDL      19.2     15.0      1.1
MAXIMA:       .063     .017      .029     .027       1.6      26.4     20.3      3.6      2645. FT.

JULIAN DAY = 215  YEAR = 1975  SUN, AUG  3  TIMES: 12:54:05 - 14:56:45  FLIGHT NO. = 183
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:       .006     BMDL      .001     .000      BMDL      20.3      9.9       .6
MAXIMA:       .097     .080      .118     .050       2.4      29.5     19.2      3.5      3527. FT.

JULIAN DAY = 216  YEAR = 1975  MON, AUG  4  TIMES: 06:46:02 - 10:09:40  FLIGHT NO. = 184
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     03       NO       NOX      SO2        CO       OAT      DPT      BSCAT     ALT (MSL)
MINIMA:       .018     BMDL      BMDL     .000      BMDL      16.2      **        .2
MAXIMA:       .065     .074      .126     .427       1.9      27.1     16.3      2.1      5575. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
               (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 217  YEAR = 1975  TUE, AUG  5  TIMES: 07:27:31 - 10:09:46  FLIGHT NO. = 185
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .004     BMDL     .002     BMDL      BMDL     20.3               .4
MAXIMA:        .080     .159     .224     .597      2.3      26.3              3.4    4092. FT.

JULIAN DAY = 217  YEAR = 1975  TUE, AUG  5  TIMES: 12:18:25 - 15:04:35  FLIGHT NO. = 186
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .002     BMDL     BMDL     .000      BMDL     21.4      9.9      .8
MAXIMA:        .108    1.320    1.340    3.950      5.9      30.6      **      9.7    4167. FT.

JULIAN DAY = 218  YEAR = 1975  WED, AUG  6  TIMES: 12:08:25 - 14:06:10  FLIGHT NO. = 187
SITES FLOWN OVER:     22   2    3    6    5    5   22
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .046     BMDL     BMDL     BMDL      BMDL     20.5     11.2      .9
MAXIMA:        .067     .019     .033     .043      2.8      24.6     16.4     2.6    2136. FT.

JULIAN DAY = 218  YEAR = 1975  WED, AUG  6  TIMES: 12:37:26 - 14:39:56  FLIGHT NO. = 188
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .023     BMDL     .003     BMDL      BMDL     16.3     10.4     1.0
MAXIMA:        .098     .025     .060     .019       .9      27.5     26.8     3.1    2936. FT.

JULIAN DAY = 219  YEAR = 1975  THU, AUG  7  TIMES: 07:19:21 - 08:13:56  FLIGHT NO. = 189
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .016     BMDL     BMDL     BMDL      BMDL     15.0     10.9      .5
MAXIMA:        .064     .035     .075     .001      1.1      20.3     19.2     2.3    1554. FT.

JULIAN DAY = 219  YEAR = 1975  THU, AUG  7  TIMES: 07:30:20 - 08:14:50  FLIGHT NO. = 190
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .022     BMDL     BMDL     BMDL      BMDL     17.1      8.9      .7
MAXIMA:        .055     .031     .063     .047      1.0      19.1     12.7     1.9    1679. FT.

JULIAN DAY = 220  YEAR = 1975  FRI, AUG  8  TIMES: 07:27:57 - 09:48:42  FLIGHT NO. = 191
SITES FLOWN OVER:     24   2    3    6    5    2    3    6    5   24
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .015     BMDL     BMDL     .000      1.3      14.7     -.8       .5
MAXIMA:        .078     .118     .163     .089       **      22.7     17.0     4.8    3710. FT.

JULIAN DAY = 222  YEAR = 1975  SUN, AUG 10  TIMES: 11:10:00 - 13:32:37  FLIGHT NO. = 192
SITES FLOWN OVER:     25   2    3    6    5    2    3    6    5   25
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .014     BMDL     .003     BMDL      BMDL     22.6     14.6     2.1
MAXIMA:        .112     .175     .243     [illegible]  .9   31.1     19.1     6.3    1696. FT.
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                        SUMMARY REPORT OF HELICOPTER DATA
             (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 223  YEAR = 1975  MON, AUG 11  TIMES: 06:37:51 - 09:27:46  FLIGHT NO. = 193
SITES FLOWN OVER:     25   2    3    6    5    2    3    6    5  25
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .002      BMDL     .002      BMDL      BMDL       **        **
MAXIMA:        .051      .221     .273      .656      3.4       29.5      27.3               2849. FT.

JULIAN DAY = 224  YEAR = 1975  TUE, AUG 12  TIMES: 07:09:36 - 09:41:31  FLIGHT NO. = 194
SITES FLOWN OVER:     25   2    3    6    5    2    3    6    5  25
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .012      BMDL     .000      BMDL      BMDL      26.2      14.6      1.5
MAXIMA:        .151      .092     .135      .003      2.8       32.1      20.3      2.8      1665. FT.

JULIAN DAY = 224  YEAR = 1975  TUE, AUG 12  TIMES: 11:23:18 - 13:18:53  FLIGHT NO. = 195
SITES FLOWN OVER:     25   2    3    6    5    2    3    6    5  25
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .035      BMDL     BMDL      BMDL      BMDL      31.6      10.9      1.3
MAXIMA:        .147      .144     .160      .139      1.8       36.8      19.6      2.6      1698. FT.

JULIAN DAY =  45  YEAR = 1976  SAT, FEB 14  TIMES: 07:29:34 - 10:02:19  FLIGHT NO. = 196
SITES FLOWN OVER:     23   2    3    6    5    2    3    6    5  23
PARAMETEPS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .036      BMDL     BMDL                BMDL       .2                 .3
MAXIMA:        .054      .032     .048                 .9       6.8                10.5      3789. FT.

JULIAN DAY =  45  YEAR = 1976  SAT, FEB 14  TIMES: 12:49:20 - 15:32:55  FLIGHT NO. = 197
SITES FLOWN OVER:     24   2    3    6    5    2    3    6    5  24
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .009      BMDL     BMDL                BMDL      6.3                 .8
MAXIMA:        .045      .146     .165                2.7       12.9                7.1      2288. FT.

JULIAN DAY =  46  YEAR = 1976  SUN, FEB 15  TIMES: 07:35:49 - 10:33:54  FLIGHT NO. = 198
SITES FLOWN OVER:     24   2    3    6    5    2    3    6    5
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .020      BMDL     BMDL      .000      BMDL      12.1      11.1       .9
MAXIMA:        .048      .076     .141      .022      1.6       20.6      13.8      1.6      3462. FT.

JULIAN DAY =  48  YEAR = 1976  TUE, FEB 17  TIMES: 07:08:37 - 08:20:02  FLIGHT NO. = 199
SITES FLOWN OVER:     23
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .001      BMDL     BMDL      BMDL      BMDL      2.7                 .4
MAXIMA:        .060      .031     .040      .067       .5       11.6                3.3      3424. FT.

JULIAN DAY =  49  YEAR = 1976  WED, FEB 18  TIMES: 13:50:15 - 14:19:35  FLIGHT NO. = 200
SITES FLOWN OVER:     21
PARAMETERS:      O3       NO       NOX      SO2       CO        OAT       DPT      BSCAT    ALT (MSL)
MINIMA:        .032      BMDL     BMDL      .000      BMDL      3.5                 .7
MAXIMA:        .046      .111     .132      .002       .8       8.9                1.0      1955. FT.
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                              SUMMARY REPORT OF HELICOPTER DATA
                  (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  50  YEAR = 1976  THU, FEB 19  TIMES: 07:19:05 - 10:13:30  FLIGHT NO. = 201
SITES FLOWN OVER:     25    2    3   6    5    2    3    6    5  25
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      .009     BMDL     BMDL     .000     BMDL    -10.6    -23.7      .4
MAXIMA:      .058     .034     .058     .002       .7      9.3      3.4     3.0     3320. FT.

JULIAN DAY =  50  YEAR = 1976  THU, FEB 19  TIMES: 12:22:40 - 13:53:30  FLIGHT NO. = 202
SITES FLOWN OVER:     25    2    3   3    3
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      .025     BMDL     BMDL     .000     BMDL      6.5    -10.3      .3
MAXIMA:      .061     .029     .044     .002      4.6     13.6      -.5      .8     2120. FT.

JULIAN DAY =  51  YEAR = 1976  FRI, FEB 20  TIMES: 07:17:35 - 11:13:15  FLIGHT NO. = 203
SITES FLOWN OVER:     24    2    3   6    5    2    3    6    5  24
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      .000     BMDL     BMDL     BMDL     BMDL      5.9    -15.8      .2
MAXIMA:      .082    1.430    1.440     .688       **     13.1     -1.8     1.9     3416. FT.

JULIAN DAY =  52  YEAR = 1976  SAT, FEB 21  TIMES: 11:01:52 - 13:59:57  FLIGHT NO. = 204
SITES FLOWN OVER:     24    2    3   6    5  24   32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      .022     BMDL     BMDL     BMDL     BMDL      6.4     -3.6      .5
MAXIMA:      .059     .060     .055     .002      2.7     15.9      6.8     1.0     3320. FT.

JULIAN DAY =  53  YEAR = 1976  SUN, FEB 22  TIMES: 07:19:21 - 08:53:11  FLIGHT NO. = 205
SITES FLOWN OVER:     22    2    3   6    5
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      BMDL     BMDL     BMDL     BMDL     BMDL     -5.3     -9.5      .5
MAXIMA:      .045     .027     BMDL     .077      8.7      -.2     -3.7     2.6     2321. FT.

JULIAN DAY =  53  YEAR = 1976  SUN, FEB 22  TIMES: 16:04:37 - 19:55:22  FLIGHT NO. = 206
SITES FLOWN OVER:     31  20  21  15   16    9  17  10  18  42  18  10  17   9  16  15  21  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      BMDL     BMDL     BMDL     BMDL     BMDL      1.2     -6.6      .5
MAXIMA:      .064     .177     .223     .260      2.7     10.8      2.6     1.5     2248. FT.

JULIAN DAY =  54  YEAR = 1976  MON, FEB 23  TIMES: 05:18:05 - 09:12:45  FLIGHT NO. = 207
SITES FLOWN OVER:     32  25  42  19    6  41    3   9  16   9   3  41   6  19  42  25  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      BMDL     BMDL     BMDL     .000     BMDL    -16.5    -29.9    BMDL
MAXIMA:        **     .147     .392     .705      2.7      3.3     -2.8     3.9     4287. FT.

JULIAN DAY =  54  YEAR = 1976  MON, FEB 23  TIMES: 15:50:57 - 18:52:32  FLIGHT NO. = 208
SITES FLOWN OVER:     32  25  42  18    6   3    9  16    9
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:      .017     BMDL     BMDL     .001       .0    -10.2    -18.4      .3
MAXIMA:      .058     .273     .293     .006       **     17.4       .6     1.3     4530. FT.
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                          SUMMARY REPORT OF HELICOPTER DATA
                 (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  55  YEAR = 1976  TUE, FEB 24  TIMES: 07:06:05 - 10:21:00  FLIGHT NO. = 209
SITES FLOWN OVER:     32  21  14   9   3  41  51  52  42  25  32
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .003    BMDL    BMDL    BMDL    BMDL     3.7   -29.0      .2
MAXIMA:         **    .001    .010    .066     4.4    18.6     -.2     1.6   4403. FT.

JULIAN DAY =  57  YEAR = 1976  THU, FEB 26  TIMES: 11:19:29 - 12:28:44  FLIGHT NO. = 210
SITES FLOWN OVER:     42
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       BMDL    BMDL    BMDL    BMDL      .6     4.7              .1
MAXIMA:       .058    .019    .035    .090     2.4    12.0             4.1   4334. FT.

JULIAN DAY =  57  YEAR = 1976  THU, FEB 26  TIMES: 14:10:46 - 15:52:36  FLIGHT NO. = 211
SITES FLOWN OVER:     61  62  63  64  65
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .000    BMDL    BMDL    .000    BMDL     9.7              .2
MAXIMA:       .042    .051    .098    .235     2.6    15.3             3.0   3134. FT.

JULIAN DAY =  57  YEAR = 1976  THU, FEB 26  TIMES: 16:22:15 - 18:17:10  FLIGHT NO. = 212
SITES FLOWN OVER:     42
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .000    BMDL    BMDL    .000      .2     9.7              .3
MAXIMA:       .002    .005    .047    .046     2.9    17.5             2.8   3475. FT.

JULIAN DAY =  58  YEAR = 1976  FRI, FEB 27  TIMES: 08:00:52 - 12:01:07  FLIGHT NO. = 213
SITES FLOWN OVER:     60  60  25   2   3   6   5  30
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .016    BMDL    BMDL    BMDL    BMDL           -16.6      .3
MAXIMA:       .076    .061    .101    .252      .7            -1.3     2.0   3401. FT.

JULIAN DAY =  59  YEAR = 1976  SAT, FEB  8  TIMES: 08:03:25 - 11:42:00  FLIGHT NO. = 214
SITES FLOWN OVER:     23   2   3   6   5   2   3   6   5  23  32
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .015    BMDL    BMDL    BMDL    BMDL     6.5      **      .2
MAXIMA:       .068     ***    .234    .024     1.0    13.0     4.6     2.9   3905. FT.

JULIAN DAY =  61  YEAR = 1976  MON, MAR  1  TIMES: 07:10:34 - 11:30:09  FLIGHT NO. = 215
SITES FLOWN OVER:     32  24   2   3   6   5   2   3   6   5  24  32
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .002    BMDL    BMDL    BMDL    BMDL      **      **      .6
MAXIMA:       .072    .161    .271    .057      **    21.2    13.6     5.2   1855. FT.

JULIAN DAY =  61  YEAR = 1976  MON, MAR  1  TIMES: 12:09:42 - 13:35:57  FLIGHT NO. = 216
SITES FLOWN OVER:      2   3   6   5
PARAMETERS:     O3      NO     NOX     SO2      CO     OAT     DPT   BSCAT   ALT (MSL)
MINIMA:       .040    BMDL    BMDL    BMDL    BMDL   -17.3      **      .8
MAXIMA:       .074    .012    .134    .[illegible]2     7.6    23.7    13.8     2.5   2077. FT.
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                          SUMMARY REPORT OF HELICOPTER DATA
               (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 06:49:33 - 07:19:53  FLIGHT NO. = 217
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL     BMDL      -5.2    -23.2      .2
MAXIMA:                ***    .229     .001       .4      -2.5     -2.6     2.6      3774. FT.

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 07:58:29 - 08:54:29  FLIGHT NO. = 218
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL     BMDL      -5.6    -23.3      .2
MAXIMA:                ***    .452     .001       .9      -1.8     -2.3     1.3      3892. FT.

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 10:19:33 - 11:01:53  FLIGHT NO. = 219
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL     BMDL      -5.5    -23.2      .3
MAXIMA:                ***    .343     .002      1.1        .8     -2.2     4.4      3926. FT.

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 13:32:01 - 15:10:06  FLIGHT NO. = 220
SITES FLOWN OVER:     20   6   3  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL     BMDL      -3.5    -20.4     BMDL
MAXIMA:                ***    .316     .002      1.6       8.1     -2.6      .9      3830. FT.

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 17:28:00 - 18:17:30  FLIGHT NO. = 221
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL     BMDL      -1.1    -13.9      .4
MAXIMA:                ***    .314     .002      1.3       8.6     -2.2      .7      3801. FT.

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 19:53:25 - 20:42:30  FLIGHT NO. = 222
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    BMDL     BMDL     BMDL      -1.2    -13.0      .4
MAXIMA:               .007    .028     .002      1.5       7.0     -1.3     1.0      3849. FT.

JULIAN DAY =  66  YEAR = 1976  SAT, MAR  6  TIMES: 21:54:54 - 22:42:44  FLIGHT NO. = 223
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:               BMDL    .000     BMDL     BMDL      -1.2    -12.0      .2
MAXIMA:               .007    .036     .002      1.1       6.2     -1.1      .9      3794. FT.

JULIAN DAY =  67  YEAR = 1976  SUN, MAR  7  TIMES: 06:44:18 - 07:36:33  FLIGHT NO. = 224
SITES FLOWN OVER:     32  21  32
PARAMETERS:    03      NO      NOX      SO2       CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:       BMDL    BMDL    BMDL     BMDL     BMDL       -.1    -22.6      .1
[illegible]   [illegible]  ***  [illegible]  [illegible]  2.0   4.1  -1.5   1.2      3777. FT.
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                        SUMMARY REPORT OF HELICOPTER DATA
               (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

ULIAN DAY =  67  YEAR = 1976  SUN, MAR  7  TIMES: 08:13:27 - 08:59:22  FLIGHT NO. = 225
ITES FLOWN OVER:     32  21  32
ARAMETERS:     O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
INIMA:        BMDL     BMDL     BMDL     BMDL      BMDL        .1    -22.8      .1
AXIMA:        .040      ***     .270     .002        **       4.0      -.8     1.2     3786. FT.

ULIAN DAY =  67  YEAR = 1976  SUN, MAR  7  TIMES: 10:20:11 - 13:28:11  FLIGHT NO. = 226
ITES FLOWN OVER:     32  20   6  88  89   3  88   6  32
ARAMETERS:     O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
INIMA:        BMDL     BMDL     BMDL     BMDL      BMDL        .4    -24.4      .1
AXIMA:        .042      ***     .149     .002        **       9.7      -.8      .8     3844. FT.

JULIAN DAY =  69  YEAR = 1976  TUE, MAR  9  TIMES: 07:36:29 - 10:49:59  FLIGHT NO. = 227
SITES FLOWN OVER:     22  22  22  22   2   3   6   5
PARAMETERS:    O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL     BMDL     BMDL               BMDL      -1.8     -3.5      .6
MAXIMA:         **    1.420    1.350                7.4       9.1      2.6     4.5     1931. FT.

JULIAN DAY =  69  YEAR = 1976  TUE, MAR  9  TIMES: 13:24:55 - 16:29:40  FLIGHT NO. = 228
SITES FLOWN OVER:      8   3   8   3   8   3   8   3   8   3   8   3   8  32
PARAMETERS:    O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .027     BMDL     BMDL               BMDL       2.6    -10.3      .5
MAXIMA:       .067     .030     .057                2.4      12.8       .9     1.6     2926. FT.

JULIAN DAY =  70  YEAR = 1976  WED, MAR 10  TIMES: 07:17:45 - 10:21:20  FLIGHT NO. = 229
SITES FLOWN OVER:     25   2   3   6   5   2   3   6   5  25
PARAMETERS:    O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .024     BMDL     BMDL     BMDL      BMDL       2.6     -2.8      .6
MAXIMA:       .074     .124     .167     .202       1.9      11.0      4.7     3.3     3341. FT.

JULIAN DAY =  70  YEAR = 1976  WED, MAR 10  TIMES: 13:16:31 - 15:28:01  FLIGHT NO. = 230
SITES FLOWN OVER:     25   2   3   6   5   2  25
PARAMETERS:    O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .026     BMDL     BMDL     .000      BMDL       3.5     -5.7      .7
MAXIMA:       .064     .035     .070     .033       1.7      16.0      7.0     3.1     3350. FT.

JULIAN DAY =  72  YEAR = 1976  FRI, MAR 12  TIMES: 09:55:09 - 10:47:30  FLIGHT NO. = 231
SITES FLOWN OVER:     71  71  70
PARAMETERS:    O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL     BMDL     .002     BMDL      BMDL      15.4      4.1      .5
MAXIMA:       .065    1.350    1.370  126.000        .7      18.6     10.9    25.6     1484. FT.

JULIAN DAY = 198  YEAR = 1976  FRI, JUL 16  TIMES: 07:27:10 - 10:03:20  FLIGHT NO. = 232
SITES FLOWN OVER:     31  25   2   3   6   5   3   6   5  32
PARAMETERS:    O3       NO       NOX      SO2       CO        OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL     BMDL     BMDL     BMDL      BMDL      19.8      9.3      .3
MAXIMA:       .054     .044     .101     .144        **      26.8     16.8     1.3     3066. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
              (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 198  YEAR = 1976  FRI, JUL 16  TIMES: 08:32:11 - 11:08:47  FLIGHT NO. = 233
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   6   5  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:               BMDL     BMDL     BMDL     BMDL     15.5      4.6      .1
MAXIMA:               .021     .010     .029      8.4     27.6     14.6     1.6    3512. FT.

JULIAN DAY = 198  YEAR = 1976  FRI, JUL 16  TIMES: 12:16:55 - 15:12:15  FLIGHT NO. = 234
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  22  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .043     BMDL     BMDL     .000     BMDL     17.0      7.2      .5
MAXIMA:      .073     .010     .023     .023      1.3     28.4     14.5     1.3    4069. FT.

JULIAN DAY = 201  YEAR = 1976  MON, JUL 19  TIMES: 06:14:26 - 09:40:41  FLIGHT NO. = 235
SITES FLOWN OVER:     31  24   2   3   6   5   2   3   6   5  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .027     BMDL     BMDL     BMDL     BMDL     21.1     11.8      .6
MAXIMA:      .116     .172     .220     .171       **     28.3     17.6     3.1    3049. FT.

JULIAN DAY = 201  YEAR = 1976  MON, JUL 19  TIMES: 07:19:06 - 10:36:13  FLIGHT NO. = 236
SITES FLOWN OVER:     31  24   2   6   5   2   3   6   5  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .022     BMDL     BMDL     BMDL     BMDL     20.3     10.3      .8
MAXIMA:      .123     .181     .238     .074      1.7     30.4     18.2     3.4    3597. FT.

JULIAN DAY = 201  YEAR = 1976  MON, JUL 19  TIMES: 12:49:06 - 14:17:51  FLIGHT NO. = 237
SITES FLOWN OVER:     31  21  15  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .000     BMDL     BMDL     BMDL     BMDL     22.6     12.3     1.5
MAXIMA:      .141     .222     .341     .274      3.7     34.5     18.9     6.1    3197. FT.

JULIAN DAY = 201  YEAR = 1976  MON, JUL 19  TIMES: 12:49:20 - 14:14:05  FLIGHT NO. = 238
SITES FLOWN OVER:     31  21  15
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .066     BMDL     BMDL     BMDL     BMDL     23.7     13.7     1.1
MAXIMA:      .142     .228     .308     .641       .8     32.8       **     3.3    3167. FT.

JULIAN DAY = 202  YEAR = 1976  TUE, JUL 20  TIMES: 06:15:33 - 09:11:20  FLIGHT NO. = 239
SITES FLOWN OVER:     31  25   2   3   6   5   2   3   6   5  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .032                       BMDL     BMDL     22.0     14.9      .8
MAXIMA:      .066                       .679      1.6     30.0     22.1     3.2    2314. FT.

JULIAN DAY = 202  YEAR = 1976  TUE, JUL 20  TIMES: 07:25:50 - 10:08:35  FLIGHT NO. = 240
SITES FLOWN OVER:     31  25   2   3   6   5   2   3   6   5  32
PARAMETERS:    O3       NO      NOX      SO2       CO      OAT      DPT    BSCAT   ALT (MSL)
MINIMA:      .031     BMDL     BMDL     .000     BMDL     22.1     15.2      .6
MAXIMA:      .083     .022     .048     .058       .7     31.0     23.1     2.4    3637. FT.
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                      SUMMARY REPORT OF HELICOPTER DATA
          (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 202  YEAR = 1976  TUE, JUL 20  TIMES: 12:38:15 - 14:11:20  FLIGHT NO. = 241
SITES FLOWN OVER:     15
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .032    BMDL     BMDL     BMDL     BMDL      29.6     14.9      .8
MAXIMA:       .096    .012     .015     .037      2.0      35.4     21.9     1.5     1679. FT.

JULIAN DAY = 204  YEAR = 1976  THU, JUL 22  TIMES: 12:28:15 - 15:16:30  FLIGHT NO. = 242
SITES FLOWN OVER:     31  99  32
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .021    BMDL     BMDL              BMDL      24.7     11.5      .5
MAXIMA:       .155    .009     .030               1.2      36.3     30.5     1.4     4121. FT.

JULIAN DAY = 205  YEAR = 1976  FRI, JUL 23  TIMES: 04:33:35 - 07:42:40  FLIGHT NO. = 243
SITES FLOWN OVER:     31  32  76  76  76  76   3  32
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL    BMDL     BMDL              BMDL      23.7      **       .9
MAXIMA:       .070    .786     .870               2.6      30.0      **      5.3     3778. FT.

JULIAN DAY = 205  YEAR = 1976  FRI, JUL 23  TIMES: 05:45:51 - 09:00:11  FLIGHT NO. = 244
SITES FLOWN OVER:     31   6   2   3   9  23  32
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .010    BMDL     BMDL              BMDL      24.9     16.4      .6
MAXIMA:       .128    .209     .274               2.4      31.4     22.3     2.9     3056. FT.

JULIAN DAY = 205  YEAR = 1976  FRI, JUL 23  TIMES: 08:36:20 - 11:28:55  FLIGHT NO. = 245
SITES FLOWN OVER:     31  81  32
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .056    BMDL     BMDL              BMDL      23.1      **       .6
MAXIMA:       .129    .011     .022                **      33.3      **      2.5     3037. FT.

JULIAN DAY = 205  YEAR = 1976  FRI, JUL 23  TIMES: 13:13:30 - 16:03:30  FLIGHT NO. = 246
SITES FLOWN OVER:     31  61  32
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .061    BMDL     BMDL              BMDL       **               .6
MAXIMA:       .145    .010     .016               1.0      35.0             4.9     4191. FT.

JULIAN DAY = 210  YEAR = 1976  WED, JUL 28  TIMES: 07:46:35 - 08:19:31  FLIGHT NO. = 247
SITES FLOWN OVER:     31  25   2   3   6   5
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .011    BMDL     BMDL     BMDL     BMDL      27.6     17.8
MAXIMA:       .168    .018     .037     .021      1.1      33.5     24.3              2170. FT.

JULIAN DAY = 211  YEAR = 1976  THU, JUL 29  TIMES: 06:13:55 - 06:50:50  FLIGHT NO. = 248
SITES FLOWN OVER:     31  32  32
PARAMETERS:     O3      NO      NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL    BMDL     .012     .020       .5      22.0     20.2      .7
MAXIMA:  [illegible] [illegible] [illegible] [illegible]  3.0      24.5     22.8     2.3     2116. FT.
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                    SUMMARY REPORT OF HELICOPTER DATA
          (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 211  YEAR = 1976  THU, JUL 29  TIMES: 17:31:49 - 23:40:18  FLIGHT NO. = 249
SITES FLOWN OVER:      31  81  82  83  84  85  86  87  88  89  90  91  92  93
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .004     BMDL     BMDL     .000     BMDL     22.5     14.8       .6
MAXIMA:       .120     .140     .212     .262      1.5     32.4     23.2      7.0    3105. FT.

JULIAN DAY = 212  YEAR = 1976  FRI, JUL 30  TIMES: 02:51:50 - 04:24:35  FLIGHT NO. = 250
SITES FLOWN OVER:      31  21
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .013     BMDL     BMDL     BMDL     BMDL     26.5     14.3       .6
MAXIMA:       .119     .802     .932     .004      2.6     34.4       **      6.9    3271. FT.

JULIAN DAY = 212  YEAR = 1976  FRI, JUL 30  TIMES: 06:21:56 - 09:56:46  FLIGHT NO. = 251
SITES FLOWN OVER:      31  24   2   3   6   5   2   3   6  32
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .010     BMDL     BMDL     .000     BMDL     16.8       **       .2
MAXIMA:       .121     .302     .408    1.010      3.1     29.4     23.8      7.7    7037. FT.

JULIAN DAY = 212  YEAR = 1976  FRI, JUL 30  TIMES: 08:27:20 - 10:33:40  FLIGHT NO. = 252
SITES FLOWN OVER:      31  90
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       BMDL     BMDL     BMDL     .000     BMDL     17.8      3.5       .4
MAXIMA:       .098     .020     .072     .133      2.8     34.5     25.0      8.2    7954. FT.

JULIAN DAY = 212  YEAR = 1976  FRI, JUL 30  TIMES: 11:17:30 - 13:37:45  FLIGHT NO. = 253
SITES FLOWN OVER:      31  32
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .046     BMDL     BMDL     .000     BMDL     16.8     -2.9       .2
MAXIMA:       .160     .020     .032     .001      1.8     33.9     27.9      3.6    7354. FT.

JULIAN DAY = 212  YEAR = 1976  FRI, JUL 30  TIMES: 14:46:15 - 16:25:15  FLIGHT NO. = 254
SITES FLOWN OVER:      31  21
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .000     BMDL     BMDL     .000     BMDL     28.7     15.5      2.1
MAXIMA:       .096     .908    1.150    1.420      1.5     38.1     22.7      7.5    3268. FT.

JULIAN DAY = 214  YEAR = 1976  SUN, AUG  1  TIMES: 10:53:00 - 12:59:50  FLIGHT NO. = 255
SITES FLOWN OVER:       8  32
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .022     BMDL     BMDL     .000     BMDL     11.8     -9.1       .1
MAXIMA:       .058     .176     .218     .133      2.3     25.3     13.5      1.5    5524. FT.

JULIAN DAY = 215  YEAR = 1976  MON, AUG  2  TIMES: 04:56:13 - 06:56:30  FLIGHT NO. = 256
SITES FLOWN OVER:      SEE FLIGHT DESCRIPTION
PARAMETERS:     03       NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:       .022     BMDL     BMDL     .000               8.9       **       .2
MAXIMA:       .078     .038     .069     .036              21.4     15.5      1.0    6997. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
              (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 215  YEAR = 1976  MON, AUG  2  TIMES: 08:04:31 - 11:06:46  FLIGHT NO. = 257
SITES FLOWN OVER:     31  22  22  22  22  22  22  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .025     BMDL     BMDL     .000      BMDL      8.5     -4.6     BMDL
MAXIMA:        .064     .009     .016     .001       3.1     26.0     12.0       .7     6870. FT.

JULIAN DAY = 215  YEAR = 1976  MON, AUG  2  TIMES: 13:17:30 - 16:12:35  FLIGHT NO. = 258
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  24  23  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .014     BMDL     .001     .000      BMDL     19.5      6.9     BMDL
MAXIMA:        .076     .109     .142     .199       2.7     27.4     11.9      1.2     3013. FT.

JULIAN DAY = 216  YEAR = 1976  TUE, AUG  3  TIMES: 04:35:40 - 06:35:20  FLIGHT NO. = 259
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .000                        .000      BMDL      8.6       **       .2
MAXIMA:        .090                       1.880       6.9     18.5     13.5      5.4     6903. FT.

JULIAN DAY = 216  YEAR = 1976  TUE, AUG  3  TIMES: 05:59:25 - 08:41:50  FLIGHT NO. = 260
SITES FLOWN OVER:     31  23   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .007     BMDL     BMDL     .000      BMDL     14.9      6.4       .3
MAXIMA:        .105     .389     .467     .704       3.1     21.4     13.4      4.1     3477. FT.

JULIAN DAY = 216  YEAR = 1976  TUE, AUG  3  TIMES: 07:29:55 - 09:26:50  FLIGHT NO. = 261
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        BMDL                        .000      BMDL      8.6       **       .2
MAXIMA:        .092                       2.580        **     21.6     14.2      4.5     6944. FT.

JULIAN DAY = 216  YEAR = 1976  TUE, AUG  3  TIMES: 10:33:35 - 13:16:50  FLIGHT NO. = 262
SITES FLOWN OVER:     31  23   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .017     BMDL     BMDL     .000      BMDL     10.8                .2
MAXIMA:        .102     .036     .081     .169       3.9     26.9               1.8     6742. FT.

JULIAN DAY = 216  YEAR = 1976  TUE, AUG  3  TIMES: 10:49:55 - 13:11:40  FLIGHT NO. = 263
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  23  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .022                        .000      BMDL     15.5      4.9       .7
MAXIMA:        .095                        .070       8.4     24.5     12.6      1.5     3015. FT.

JULIAN DAY = 216  YEAR = 1976  TUE, AUG  3  TIMES: 15:31:21 - 17:46:46  FLIGHT NO. = 264
SITES FLOWN OVER:     31   2   3   6   5  23   6  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .015                        .000      BMDL     20.8      6.3       .6
MAXIMA:        .153                        .622        **     25.8     10.7      2.0     2170. FT.
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                           SUMMARY REPORT OF HELICOPTER DATA
                  (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 217  YEAR = 1976  WED, AUG  4  TIMES: 05:04:45 - 06:18:05  FLIGHT NO. = 265
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .016    BMDL     BMDL     .000     BMDL     9.7              .5
MAXIMA:       .106    BMDL     .067     .097     2.7     22.0             1.5     7190. FT.

JULIAN DAY = 217  YEAR = 1976  WED, AUG  4  TIMES: 07:34:40 - 10:29:05  FLIGHT NO. = 266
SITES FLOWN OVER:     31  24   2   3   6   5   2   3   6   5  32
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .025    BMDL     BMDL     .000     BMDL    18.4              .7
MAXIMA:       .114    BMDL     .157     .001     4.8     27.4             2.2     3208. FT.

JULIAN DAY = 217  YEAR = 1976  WED, AUG  4  TIMES: 08:10:40 - 10:15:40  FLIGHT NO. = 267
SITES FLOWN OVER:     31
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .053    BMDL     BMDL     .000     BMDL     9.5      **      .1
MAXIMA:       .195    .029     .088     .363      **     25.0     14.5    2.2     8454. FT.

JULIAN DAY = 217  YEAR = 1976  WED, AUG  4  TIMES: 12:52:21 - 15:57:01  FLIGHT NO. = 268
SITES FLOWN OVER:     31  32
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .008    BMDL     BMDL     BMDL     BMDL    15.8      7.3    1.0
MAXIMA:       .211    .007     .040     .001      **     29.5     12.6    1.9     4589. FT.

JULIAN DAY = 217  YEAR = 1976  WED, AUG  4  TIMES: 17:19:33 - 19:35:28  FLIGHT NO. = 269
SITES FLOWN OVER:     61
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .036    BMDL     .000     BMDL     BMDL    16.8      7.5     .9
MAXIMA:       .122    .010     .041     .092     1.6     29.0     14.5    2.2     4501. FT.

JULIAN DAY = 219  YEAR = 1976  FRI, AUG  6  TIMES: 06:20:20 - 07:53:25  FLIGHT NO. = 270
SITES FLOWN OVER:     31  25   2   3  32
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .007    BMDL     BMDL     BMDL     BMDL    18.7     10.9     .3
MAXIMA:       .058    .018     .006     .001     3.8     23.8     21.1    6.4     2916. FT.

JULIAN DAY = 220  YEAR = 1976  SAT, AUG  7  TIMES: 06:04:15 - 08:39:45  FLIGHT NO. = 271
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   6   5  32
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .009    BMDL     BMDL     BMDL             12.0      **      .3
MAXIMA:       .061    .044     .058     .001             20.7     15.7    3.7     6909. FT.

JULIAN DAY = 220  YEAR = 1976  SAT, AUG  7  TIMES: 07:08:15 - 09:50:45  FLIGHT NO. = 272
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   6   5  32
PARAMETERS:     03      NO      NOX      SO2      CO      OAT      DPT    BSCAT    ALT (MSL)
MINIMA:       .020    BMDL     BMDL     .000     BMDL    12.2      **      .1
MAXIMA:       .067    .056     .091     .044     2.5     23.3     14.9    3.7     6648. FT.
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                      SUMMARY REPORT OF HELICOPTER DATA
            (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 220  YEAR = 1976  SAT, AUG  7  TIMES: 11:02:01 - 13:56:51  FLIGHT NO. = 273
SITES FLOWN OVER:      2   3   6   5   2   3   5   6  22
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .031    BMDL    BMDL     BMDL               9.5    -11.0      .2
MAXIMA:         .077    .027    .049     .001              25.4     14.0     1.8     8117. FT.

JULIAN DAY = 220  YEAR = 1976  SAT, AUG  7  TIMES: 12:13:25 - 15:11:00  FLIGHT NO. = 274
SITES FLOWN OVER:     31   2   6   5   2   3   6   5  22  32
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .039    BMDL    BMDL     .000     BMDL     10.9     -9.3      .1
MAXIMA:         .081    .022    .048     .001      5.9     25.6     12.9     1.9     6871. FT.

JULIAN DAY = 221  YEAR = 1976  SUN, AUG  8  TIMES: 04:38:14 - 07:45:36  FLIGHT NO. = 275
SITES FLOWN OVER:     SEE FLIGHT DESCRIPTION
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .003    BMDL    BMDL     .000     BMDL     11.2      **      BMDL
MAXIMA:         .085   1.400   1.400    2.280      5.3     19.6     13.5     7.9     6813. FT.

JULIAN DAY = 221  YEAR = 1976  SUN, AUG  8  TIMES: 06:35:18 - 09:30:08  FLIGHT NO. = 276
SITES FLOWN OVER:     31  32
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         BMDL    BMDL    BMDL     BMDL              13.0      **       .2
MAXIMA:         .077    .824    .946    1.240              22.5     14.2     3.6     7209. FT.

JULIAN DAY = 222  YEAR = 1976  MON, AUG  9  TIMES: 11:21:55 - 13:22:47  FLIGHT NO. = 277
SITES FLOWN OVER:     31  24   2   3   6   5   2   3   6   5  32
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .016    BMDL    BMDL     BMDL              18.3               .3
MAXIMA:         .072    .036    .061     .104              29.4              1.2     3075. FT.

JULIAN DAY = 223  YEAR = 1976  TUE, AUG 10  TIMES: 06:45:15 - 09:29:35  FLIGHT NO. = 278
SITES FLOWN OVER:     31  24   2   3   6   5  32
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .012    BMDL    BMDL     BMDL              21.5      6.9      .2
MAXIMA:         .264    .056    .112     .218               **      30.8     1.7     3032. FT.

JULIAN DAY = 224  YEAR = 1976  WED, AUG 11  TIMES: 12:16:15 - 16:18:20  FLIGHT NO. = 279
SITES FLOWN OVER:     31   2   2   3   6   5   2   3   6   5  32
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .047    BMDL    BMDL     .000     BMDL     22.1     10.1      .5
MAXIMA:         .108    .042    .094     .047      3.5     33.6     22.8     3.1     5062. FT.

JULIAN DAY = 225  YEAR = 1976  THU, AUG 12  TIMES: 06:20:40 - 08:42:36  FLIGHT NO. = 280
SITES FLOWN OVER:     31  32
PARAMETERS:      03      NO      NOX      SO2       CO      OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         BMDL    BMDL    BMDL     BMDL              24.4     12.7      .1
MAXIMA:         .054   1.410   1.280    2.770              28.0      **      5.9     3633. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
               (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 225  YEAR = 1976  THU, AUG 12  TIMES: 06:20:38 - 09:06:35  FLIGHT NO. = 281
SITES FLOWN OVER:     31  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .005     BMDL     BMDL     .000      BMDL       **      12.6       .9
MAXIMA:        .079    1.280    1.380    3.050       5.2     28.0      20.6      7.7      3513. FT.

JULIAN DAY = 226  YEAR = 1976  FRI, AUG 13  TIMES: 07:56:45 - 10:02:43  FLIGHT NO. = 282
SITES FLOWN OVER:      2   3   6   5   2   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .004     BMDL     BMDL     .000                 24.3     17.3     BMDL
MAXIMA:        .122     .253     .339     .033                 30.6     22.3      4.2      3088. FT.

JULIAN DAY = 226  YEAR = 1976  FRI, AUG 13  TIMES: 07:59:41 - 10:41:11  FLIGHT NO. = 283
SITES FLOWN OVER:     31  25  25  25  25  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .018     BMDL     BMDL               BMDL     23.9     14.9      1.5
MAXIMA:        .090     .017     .049                1.8     30.2     22.3      3.8      3058. FT.

JULIAN DAY = 300  YEAR = 1976  TUE, OCT 26  TIMES: 05:59:55 - 08:54:44  FLIGHT NO. = 284
SITES FLOWN OVER:     31  23   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .003     BMDL     BMDL               BMDL     -5.6    -12.1       .5
MAXIMA:        .050     .783     .986                3.3      7.0      2.9      5.2      7096. FT.

JULIAN DAY = 300  YEAR = 1976  TUE, OCT 26  TIMES: 10:37:48 - 13:05:24  FLIGHT NO. = 285
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  23  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .020     BMDL     BMDL               BMDL      2.4    -10.3       .6
MAXIMA:        .053     .129     .176                3.2     11.5      1.9      2.9      3369. FT.

JULIAN DAY = 301  YEAR = 1976  WED, OCT 27  TIMES: 06:09:36 - 07:49:00  FLIGHT NO. = 286
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   6   5
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .000     BMDL     .001                 .0       .6     -1.1      1.2
MAXIMA:        .012     .100     .136                3.8      4.4      1.4      3.5      1588. FT.

JULIAN DAY = 301  YEAR = 1976  WED, OCT 27  TIMES: 10:25:44 - 12:38:24  FLIGHT NO. = 287
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  22  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        BMDL     .002     BMDL               BMDL       .6     -1.4      1.1
MAXIMA:        .028     .205     .242                2.7      6.9      1.9      6.7      2174. FT.

JULIAN DAY = 302  YEAR = 1976  THU, OCT 28  TIMES: 09:58:00 - 12:35:00  FLIGHT NO. = 288
SITES FLOWN OVER:     31  24   2   3   6   5   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2        CO       OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .011     BMDL     BMDL               BMDL     -2.2     -9.1       .7
MAXIMA:        .043     .135     .167                3.9      7.9       .1      2.4      3440. FT.
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                    SUMMARY REPORT OF HELICOPTER DATA
           (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 302  YEAR = 1976  THU, OCT 28  TIMES: 13:40:08 - 16:03:08  FLIGHT NO. = 289
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  24  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .016    BMDL    BMDL             BMDL     1.1      **       .1
MAXIMA:        .044    .126    .165              3.2    10.4    -1.0      1.9     4417. FT.

JULIAN DAY = 303  YEAR = 1976  FRI, OCT 29  TIMES: 07:11:16 - 09:39:44  FLIGHT NO. = 290
SITES FLOWN OVER:     31  25   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .001    BMDL    BMDL    .001     BMDL     2.8   -15.6       .4
MAXIMA:        .043    .759    .900    .992       **     8.0    -1.1      4.1     3381. FT.

JULIAN DAY = 303  YEAR = 1976  FRI, OCT 29  TIMES: 11:20:00 - 13:55:20  FLIGHT NO. = 291
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  24  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .013    BMDL    BMDL    .001     BMDL     6.1      **       .2
MAXIMA:        .046    .125    .153    .120      3.2    13.6    -1.1      3.2     3912. FT.

JULIAN DAY = 306  YEAR = 1976  MON, NOV  1  TIMES: 09:01:12 - 11:49:24  FLIGHT NO. = 292
SITES FLOWN OVER:     31  24   2   3   4   5   2   3   6   5  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .008    BMDL    BMDL    .001     BMDL     4.9   -21.9       .3
MAXIMA:        .052    .164    .211    .154       .8    12.8     3.1      4.2     4536. FT.

JULIAN DAY = 306  YEAR = 1976  MON, NOV  1  TIMES: 13:56:02 - 16:32:34  FLIGHT NO. = 293
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  24  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .022    BMDL    BMDL    .004     BMDL    11.0    -4.0       .4
MAXIMA:          **    .110    .137    .063      5.2    16.6      .9      1.7     1928. FT.

JULIAN DAY = 307  YEAR = 1976  TUE, NOV  2  TIMES: 07:42:31 - 09:51:59  FLIGHT NO. = 294
SITES FLOWN OVER:     25   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .008    BMDL    BMDL    .000     BMDL     8.5     1.6       .9
MAXIMA:        .068    .077    .125    .309      2.5    13.6     5.8      1.9     2018. FT.

JULIAN DAY = 307  YEAR = 1976  TUE, NOV  2  TIMES: 11:35:40 - 13:52:16  FLIGHT NO. = 295
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  25  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .031    BMDL    BMDL    BMDL     BMDL    11.7     4.0       .9
MAXIMA:        .074    .156    .210    .079      6.4    19.2     8.6      1.9     1965. FT.

JULIAN DAY = 308  YEAR = 1976  WED, NOV  3  TIMES: 07:16:04 - 10:17:48  FLIGHT NO. = 296
SITES FLOWN OVER:     31  25  25  25   2   3   6   5   2   3  32
PARAMETERS:     O3      NO      NOX     SO2      CO      OAT      DPT     BSCAT     ALT (MSL)
MINIMA:        .008    BMDL    BMDL    BMDL     BMDL     4.6   -22.1       .2
MAXIMA:        .047    .452    .550   1.100      2.2    10.2    -5.1      2.1     2911. FT.
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                         SUMMARY REPORT OF HELICOPTER DATA
               (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 308  YEAR = 1976  WED, NOV  3  TIMES: 11:47:58 - 15:02:38  FLIGHT NO. = 297
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  25  25  25  32
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .013     BMDL     BMDL     BMDL     BMDL      6.7     -20.4      .1
MAXIMA:        .047     .158     .261     .398       **     13.8      -7.3      .9      2211. FT.

JULIAN DAY = 309  YEAR = 1976  THU, NOV  4  TIMES: 07:17:08 - 10:22:08  FLIGHT NO. = 298
SITES FLOWN OVER:     31  22  22  22   2   3   6   5   2   3   6   5
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .017     BMDL     BMDL              BMDL     -4.9     -10.8      .5
MAXIMA:        .033     .021     .165               1.5      2.4      -3.6     2.4      3286. FT.

JULIAN DAY = 309  YEAR = 1976  THU, NOV  4  TIMES: 11:47:29 - 14:43:41  FLIGHT NO. = 299
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  22  22  22  32
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .014     BMDL     BMDL              BMDL     -4.1     -10.3      .5
MAXIMA:        .037     .092     .115               3.1      3.9      -5.5     1.2      2779. FT.

JULIAN DAY = 310  YEAR = 1976  FRI, NOV  5  TIMES: 07:09:48 - 10:18:48  FLIGHT NO. = 300
SITES FLOWN OVER:     31  25  25  25   2   3   6   5   2   3   6   5  32
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .000     BMDL     BMDL              BMDL     -3.7     -10.7      .5
MAXIMA:          **     .648     .760               2.4      3.0      -4.3     3.6      2393. FT.

JULIAN DAY = 311  YEAR = 1976  SAT, NOV  6  TIMES: 12:33:02 - 15:54:18  FLIGHT NO. = 301
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  25  25  25  32
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .011     BMDL     BMDL     BMDL     BMDL      9.0      -4.0      .5
MAXIMA:        .059     .141     .193     .982      3.4     17.2       3.0     1.7      2949. FT.

JULIAN DAY = 313  YEAR = 1976  MON, NOV  8  TIMES: 06:54:36 - 09:46:42  FLIGHT NO. = 302
SITES FLOWN OVER:     31  22  22  22   2   3   6   5   2   3   6   5
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .004     BMDL     BMDL     .000     BMDL     -4.3     -21.9      .7
MAXIMA:        .050     .209     .290     .271      3.8       .0      -9.4    10.8      2324. FT.

JULIAN DAY = 313  YEAR = 1976  MON, NOV  8  TIMES: 13:17:06 - 15:16:22  FLIGHT NO. = 303
SITES FLOWN OVER:     50
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .002     BMDL     BMDL     BMDL     BMDL      1.8        **      .2
MAXIMA:        .054    1.210    1.370    3.150      1.0      9.0     -13.3     7.1      4269. FT.

JULIAN DAY = 314  YEAR = 1976  TUE, NOV  9  TIMES: 08:11:00 - 11:40:06  FLIGHT NO. = 304
SITES FLOWN OVER:     31  25  25  25   2   3   6   5   2   3   6   5  32
PARAMETERS:     03       NO      NOX      SO2       CO       OAT       DPT     BSCAT     ALT (MSL)
MINIMA:        .020     BMDL     BMDL     BMDL     BMDL      7.3      -5.6      .2
MAXIMA:        .034     .058     .178     .144      5.3     17.2       1.3     1.1      2794. FT.
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                     SUMMARY REPORT OF HELICOPTER DATA
           (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 314  YEAR = 1976  TUE, NOV  9  TIMES: 13:21:08 - 15:06:44  FLIGHT NO. = 305
SITES FLOWN OVER:     50
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .036     BMDL     BMDL     BMDL     BMDL       9.4     -5.8      .2
MAXIMA:        .060     .692     .768    1.610      4.8      19.0       .0     1.6     3912. FT.

JULIAN DAY = 315  YEAR = 1976  WED, NOV 10  TIMES: 08:08:29 - 11:07:49  FLIGHT NO. = 306
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   5  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .009     BMDL     BMDL     .000     BMDL        .0     -9.0      .4
MAXIMA:        .039     .280     .341     .137      4.9       6.9     -3.7     1.2     2319. FT.

JULIAN DAY = 315  YEAR = 1976  WED, NOV 10  TIMES: 12:20:12 - 14:53:00  FLIGHT NO. = 307
SITES FLOWN OVER:     31   2   3   6   5   2   3   6   5  25  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .008     BMDL     BMDL     BMDL       .0       1.8     -7.1      .5
MAXIMA:        .046     .278     .323     .152      6.0      10.1     -4.2     1.5     2436. FT.

JULIAN DAY = 316  YEAR = 1976  THU, NOV 11  TIMES: 07:55:48 - 10:11:13  FLIGHT NO. = 308
SITES FLOWN OVER:     31  31  22   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .003     BMDL     BMDL     BMDL     BMDL      -5.3    -15.4      .2
MAXIMA:        .048     .301     .387     .160      3.0       4.0     -5.9     3.5     3759. FT.

JULIAN DAY = 316  YEAR = 1976  THU, NOV 11  TIMES: 11:21:00 - 14:11:20  FLIGHT NO. = 309
SITES FLOWN OVER:     31   3   6   5   2   3   6   5  22  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .014     BMDL     BMDL     BMDL     BMDL      -4.1    -11.0     1.6
MAXIMA:        .036     .109     .148     .106      3.1       2.5     -6.8     3.4     2347. FT.

JULIAN DAY = 317  YEAR = 1976  FRI, NOV 12  TIMES: 06:48:08 - 10:02:56  FLIGHT NO. = 310
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   6   5  32
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .000     BMDL     BMDL     .000     BMDL      -6.1    -12.8      .7
MAXIMA:        .037     .641     .789    1.640       **      -1.0     -6.5     3.9     2018. FT.

JULIAN DAY = 317  YEAR = 1976  FRI, NOV 12  TIMES: 11:46:20 - 13:58:27  FLIGHT NO. = 311
SITES FLOWN OVER:     50
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .003     BMDL     BMDL     .001     BMDL      -7.6    -16.2      .2
MAXIMA:        .039     .785     .913    2.200      1.7       2.3     -7.9     4.1     4305. FT.

JULIAN DAY = 320  YEAR = 1976  MON, NOV 15  TIMES: 06:49:16 - 10:04:20  FLIGHT NO. = 312
SITES FLOWN OVER:     31  22   2   3   6   5   2   3   6   5
PARAMETERS:     O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:        .000     BMDL     BMDL     BMDL     BMDL      -2.2    -13.3      .6
MAXIMA:        .078     .533     .609     .548      5.5       4.1     -3.9     8.1     2450. FT
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                      SUMMARY REPORT OF HELICOPTER DATA
           (GAS DATA IN PPM, OAT AND DPT IN DEG C., BSCAT IN 1/M)

JULIAN DAY = 320  YEAR = 1976  MON, NOV 15  TIMES: 11:22:24 - 13:42:44  FLIGHT NO. = 313
SITES FLOWN OVER:      31   2   3   6   5   2   3   6   5  23
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .001     BMDL     BMDL     .001      BMDL      -.5    -18.4      .1
MAXIMA:         .052    1.220    1.300     .070       **       9.3     -1.3    12.0     2967. FT.

JULIAN DAY = 321  YEAR = 1976  TUE, NOV 16  TIMES: 07:06:33 - 09:59:13  FLIGHT NO. = 314
SITES FLOWN OVER:      31  24   2   3   6   5   2   3   6   5  32
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         BMDL                       BMDL      BMDL     -2.7     -9.1      .7
MAXIMA:         .043                      1.860       6.0      6.1      -.9     9.5     2348. FT.

JULIAN DAY = 321  YEAR = 1976  TUE, NOV 16  TIMES: 11:08:52 - 13:50:28  FLIGHT NO. = 315
SITES FLOWN OVER:      31   2   3   6   5   2   3   6   5  24  32
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .010                       .007      BMDL      3.8     -8.3      .6
MAXIMA:         .053                       .310       2.4     10.4     -1.0     3.8     2906. FT.

JULIAN DAY = 322  YEAR = 1976  WED, NOV 17  TIMES: 09:23:28 - 12:38:48  FLIGHT NO. = 316
SITES FLOWN OVER:      31  25   2   3   6   5  32
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .008     BMDL     BMDL     .000      BMDL      1.9    -13.8      .2
MAXIMA:         .052     .099     .147     .514       4.3     12.3      2.5     3.7     2885. FT.

JULIAN DAY = 322  YEAR = 1976  WED, NOV 17  TIMES: 13:30:52 - 16:00:44  FLIGHT NO. = 317
SITES FLOWN OVER:      31   2   2   3   6   5   2   3   6   5  25  32
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .027     BMDL     BMDL     .001      BMDL      9.0     -6.1      .4
MAXIMA:         .055     .033     .051     .143       3.9     17.2      4.4     2.1     2982. FT.

JULIAN DAY = 323  YEAR = 1976  THU, NOV 18  TIMES: 07:00:01 - 10:25:25  FLIGHT NO. = 318
SITES FLOWN OVER:      31  25   2   3   6   5   2   3   6   5  32
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .005     BMDL     BMDL               BMDL      4.5     -7.0      .3
MAXIMA:         .057     .283     .366                7.8     16.2      4.9     3.8     2890. FT.

JULIAN DAY = 323  YEAR = 1976  THU, NOV 18  TIMES: 11:42:52 - 14:39:16  FLIGHT NO. = 319
SITES FLOWN OVER:      31   2   3   6   5   2   3   6   5  25  32
PARAMETERS:      O3       NO       NOX      SO2       CO       OAT      DPT     BSCAT    ALT (MSL)
MINIMA:         .018     BMDL     BMDL               BMDL     14.2               .2
MAXIMA:         .082     .198     .245                4.4     26.1               3.4     3022. FT.
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APPENDIX G

METRIC CONVERSION TABLE

English unit	Multiply by	to obtain metric unit
foot	0.3048	meter
inch	2.54	centimeter
knot	0.5144	meters per second
millibar	100	pascal
nautical mile	1,852	meters
mile	1.609	kilometers